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GLIMPSES

INTO

THE LIFE OF INDIAN PLANTS

AN ELEMENTARY INDIAN BOTANY

BY

I. PFLEIDERER

SECOND EDITION, REVISED AND ENLARGED

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PREFACE TO THE FIRST EDITION

SOME years ago I was asked by a number of friends in Mangalore to help them in the study of Botany. The promise given at that time led me to compile this little book, which, I hope, will rouse their interest in the life of plants they were so anxious to know.

At the same time I was prompted to come forward in writing a simple book on Indian Botany by the sad disappointment I felt when I witnessed the poor and lifeless way in which object-lessons on plants were taught in our elementary schools. I understood that, if any improvement in this subject was to be made, the teachers themselves had first to be interested in nature-study. And as a treatment of Botany in the old way could not secure the object in view, I adopted a course which I was glad to find in DR. O. SCHMEIL'S Manual of Botany, intended to open to any student of ordinary intelligence an understanding of plant-life and to enlarge and quicken in him a sense of that infinite harmony which runs through every part of the Creator's marvellous plan of nature, which would make the educational value of this subject equal to that of any other subject taught in schools.

To this end I combined the structural description of plants with a plain description of their vital processes. The technical terms, which so often form the crux of beginners, are reduced to the smallest number possible, and many statements are illustrated by suitable cuts. The illustrations may also be supplemented by the coloured plates of Indian Plants, published by the Basel Mission Book and Tract Depository, Mangalore, at a very moderate

price, to which reference is made in the text, wherever possible, and of which the 8 coloured pictures found in the book, are reduced reproductions.

I need hardly emphasize that in using this manual as a school-book the plants studied are to be put into the student's hand, and that the types described should, if the climate permits, be planted in a school garden for the continued observation of the various stages of their life. Many of them may, at least in the West Coast of India, be procured in any field, wood, or garden.

The book does not aim at completeness, which is not required in a school-book. Yet, the natural orders selected are systematically grouped and the characters of the various classes and divisions are briefly stated, so as to give the student at once an insight into the classification of the vegetable kingdom. . . . .

Mangalore, 1908. ***I. P.***

PREFACE TO THE SECOND EDITION

The present little volume has in its first edition been more favourably received by the public than I ever expected. I ascribe this success more to the growing interest in the subject than to the merits of the book itself. Above all, I beg to offer my sincere thanks to the educational departments in the South and North of India for the kind recognition of my work.

The printing of a new edition has been taken advantage of to make some corrections and to introduce new matter, so as to increase the usefulness of the book. If I have erred on the side of excess, I trust my readers will find it easier to eliminate than to insert.

I am told that the types selected to represent the several families are not common to all parts of India. My personal knowledge of the Indian flora being more or less limited to the West Coast, I do not know whether it would be possible to find out type-species suiting all parts of this great Peninsula. I must, therefore, leave it to my readers to substitute other types from the number of genera and species mentioned in each family.

For the identification of plants I recommend any one of the books on the Flora of India named in the bibliography, page 252. Nairne's *Flowering Plants of Western India* is particularly useful for residents of the West Coast.

The nomenclature and classification have not been materially changed and are those of BENTHAM and HOOKER.

In using this book for school purposes I beg to offer the following suggestions to teachers:—

(1) The book does not contain a scheme of lessons, but should be used as a storehouse from which the teacher may draw.

(2) The following curriculum may, perhaps, suggest itself to teachers of High Schools in Southern India:

First year.—Descriptions of individual plants, such as Lotus, Cotton tree, Mango tree, Bean, Cucumber, Sunflower, Bindweed, Chillies, Tumbe, Banyan tree, Cocoanut palm, Kesu (Taro), Gloriosa, Banana, Rice, Fern.

Second year.—Structure and Life of plants: Leaf, Root, Stem (pp. 193—228).

Third year.—Floral Biology: Flower, Fruit, and Seed (pp. 229—248).

Fourth year.—Factors determining the life and structure of plants:—

The Water: Roots and their functions.—Transpiration.—Hygrophytes.—Xerophytes.—Tropophytes.—Water and Marsh plants.

The Light: Assimilation. — Thirst for light. — Climbers. — Protection from intense light.

The Soil: Whether porous or not, whether manured or not. — Geological formations. — Mangrove. — Flora of dunes.—Epiphytes and Parasites. — Saprophytes and Carnivorous plants. — Symbiotic plants.

The Air: Mechanical and physiological effects of the wind. — Strength of Stems. — Rarification of air in high mountains.

I am deeply convinced that Botany is pre-eminently the branch of Science most fitted for the young. And if by putting forth this book I have done anything to rouse the interest of those who teach and those who learn for this noble and pleasurable study, I shall have been largely rewarded for my efforts.

Udipi,
October 31st, 1911.

I. Pfleiderer.

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FIRST PART.

DESCRIPTION OF TYPES AND FAMILIES.

DIVISION I.

FLOWERING PLANTS (Phanerogamæ).

All plants in this division have stamens and pistils, and form seeds.

CLASS I.—DICOTYLEDONS.

Plants with 2 seed-leaves. Leaves net-veined. Parts of flower usually in sets of 5 or 4. Stems, if woody, consisting of a woody substance growing in circles round a central pith, and surrounded by bark.

SUB-CLASS I.—POLYPETALÆ.

Plants generally with 2 floral envelopes: calyx and corolla. Petals separated from one another.

1. The Water-Lily Family.

(Nymphæaceæ.)

Aquatic herbs. Flowers radial. Petals and stamens numerous, inserted on the receptacle. Ovary superior, syncarpous, *i. e.* formed of (many) cohering carpels.

The Lotus Water-Lily *(Nymphæa lotus)*.

(Plate No. 623.)*

(*Can.* Naidile, Tāvare. *Mal.* Veḷḷānpal, Nīrāmpal. *Tam.* Veḷḷāmbal, Indiravāčam. *Tel.* Allikāḍa. *San.* Sītōtpala.)

Many quiet tanks and peaceful lakes are adorned by the beautiful Lotus flower. The broad leaves spreading over the

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* Plate No. 623 of Mangalore Series of Coloured Pictures of Indian Plants and Trees.

surface of the water like floating shields, and the lovely flowers like large white floating lilies, increase the mysterious charm that all still waters possess in the sunshine. No wonder, that many myths have arisen about this plant, and that it is almost worshipped by many nations!

Most plants soon die, if their roots and stems are kept under water. Not so the Lotus; for it lives there, and its structure is wonderfully adapted to a life in such surroundings.

1. The **Stem** is thick and tuber-like, with many scars which show where the leaves formerly grew. It creeps along the ground sending forth shoots at its upper end and decaying at the other. Such a stem is called a root-stock or rhizome. It sends down stout, long roots into the soft mud so that it may not be carried away by any movements of the water in which it grows.

2. From the stem rise the long stalked **Leaves,** which so long as they are below the surface are rolled up with their edges inward. As soon as the leaves reach the surface the stalk ceases to grow, and the leaves unroll their broad blades for the sun and air to play on. To these, like all other green plants, the Lotus must have access in order to feed and breathe. When the water rises to a higher level, the stalks stand vertically; when the level sinks lower, they move more and more sideways, like the ribs of an umbrella which is being opened.

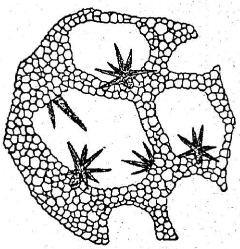

Fig. 1.—Transverse section of the leaf-stalk of the Water-lily with large air-chambers and bristles within.

If one of the leaves is torn off the stem, it will float. This is due to air-chambers in the stalk, which can be easily seen if the long stalk is cut across (fig. 1). The chambers contain bristles which serve as a means of protection against the voracious water-snails, which would otherwise feed on the leaf-stalk and so destroy the leaves.

The upper side of the leaves is covered with a wax-like substance, so that any water which may fall on them runs off, as it would from a duck's back. We may

also notice that the middle of the leaf where the stalk joins it, is a little higher than its edges which are slightly waved. This helps the water to run off. If the water were to remain on the leaves it would hinder the growth of the plant by stopping up the little holes (stomata) through which the plant breathes and absorbs carbon dioxide, a gas which, with the aid of water, the plant is able in the sunlight to turn into starch and thus gain the carbon which forms an essential element in all plants.

The openings in land plants are more numerous on the lower side of the leaves, but in the Lotus they are all on the top, because the lower side of the leaf rests on the water, and they would be of no use on that side. Put the blade of a leaf under water and blow down the stalk, and you will soon see little silvery bubbles form on the top-side of the leaf: this is the air escaping through the stomata. The air can thus communicate with the root-stock and the roots. This is important for the life of the plant. Every living part of a plant must be accessible to the oxygen in the air. Now, the muddy soil in which the Lotus grows has scarcely any oxygen, as it is used up in decomposing the dead vegetable substances deposited there. It is through the air-channels in the leaf-stalks that the life-sustaining air can penetrate down to the very root of the plant.

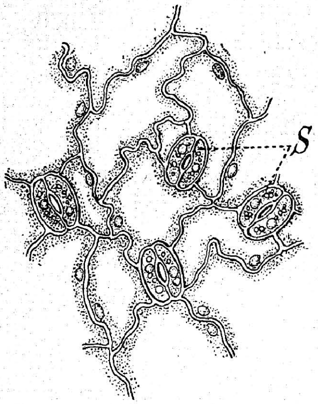

Fig. 2.—Part of the epidermis of a leaf (200 times enlarged). *S*. Stomata.

Another point about the leaves is worthy of notice: the lower side is of a darker colour than the upper, the reason for this being that dark coloured things absorb heat better than light coloured ones. (A black coat is much hotter in the sun than a white one.) Now the heat rays which accompany the light rays

from the sun would pass through the leaves into the water, if they were bright green throughout; but the violet colour absorbs the heat rays and thus assists the growth of the plant. Increase of heat causes quicker growth.

When the tank in which the Lotus grows dries up, the leaves with their long stalks sink down in the mud and perish. The plant, however, does not die with the leaves. For, when the tank is filled with water again, the root-stock (stem) which was hidden in the mud begins to sprout again, and the plant is thus perennial.

3. The **Flower** also floats on the surface of the water at the end of a long stalk. The four green sepals form a good protection to the tender bud on its journey to the top, and as soon as it arrives there, the sepals open out looking like small boats. Their inner side is the same colour as the petals. These latter are very numerous and grow in a spiral, gradually becoming smaller towards the centre and at the same time turning into stamens (fig. 3, 2). In the centre is the ovary or seed-box bearing a shield-like sessile stigma. A transverse section of the ovary (see fig. 3, 5) shows that it is composed of many leaves called carpels, which are folded in towards the floral axis and thus form several cavities in which the seeds ripen.

The flowers open after sunrise and are visited by insects which are attracted by the colour. They, however, only find pollen, as the plant secretes no honey. Towards evening the flower closes again to protect the delicate stigma and the pollen from damp and cold.

4. The **Fruit**, a spongy berry (fig. 3, 4), ripens below the surface of the water. When the seeds are ripe and leave the berry, a small bubble of air, attached to them, brings them to the surface, and the seeds are carried wherever the wind and waves take them until the bubble bursts. The seed being heavier than water sinks to the bottom and begins to grow to form a new plant which may be at some distance from the parent one. In this simple way the Lotus plant is enabled to spread.

2. Other Water-Lilies.

There is a red variety of the Lotus, *viz.: Nymphæa lotus var. rubra* (*Can.* Kennedile, Kendāvare), which is the **Egyptian**

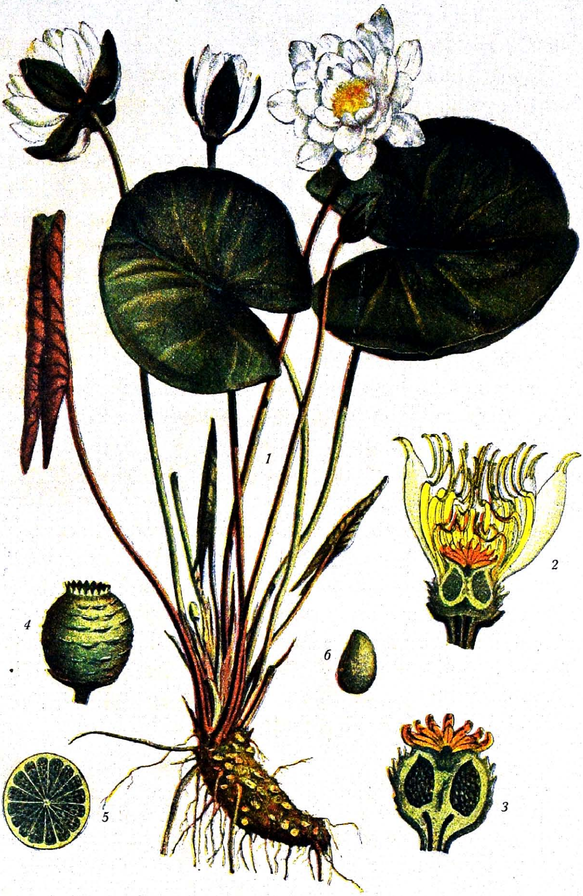

Fig. 3.—WATER-LILY *(Nymphæa lotus)*.

2. Vertical section of flower. 3. Vertical section of ovary. 4. Capsule.
5. Transverse section of it. 6. Seed.

Lotus. The smaller sort of Nymphæa, *N. stellata,* has red, white, or blue flowers. The **Sacred Lotus** of India is *Nelumbium speciosum* (*San.* Padmā). The funnel shaped leaves and the large rosy flowers are raised over the surface of the water. The root-stock and the seeds are eaten.

3. Allied families are the following:—

The *Anonaceæ* with the **Custard Apple** (*Anona squamosa; Can.* Sītāphala; *Mal.* Āttačakka; *Tam.* Āttāmaram; *San.* Šubhā), everywhere grown for its delicious fruits.

The *Menispermaceæ* with *Cyclea peltata* (*Can.* Pāḍāvaḷi; *Mal.* Pāṭakkiṭaṅṇu; *Tam.* Pāḍā; *San.* Pāṭhā), a common climber with peltate, hairy leaves.

2. The Poppy Family.

(Papaveraceæ.)

Herbs with milky juice. Flowers radial. Sepals 2, petals 4, stamens many, inserted on the receptacle. Ovary superior, syncarpous.

The Opium Poppy (*Papaver somniferum*).

(*Can.* Kasakase. *Mal.* Kaçakaça. *Tam.* Gasagasā. *Tel.* Gasagasa.)

The Opium Poppy is widely cultivated in India, because it yields *"opium"*, which is an important article of commerce. Opium is a valuable drug which can soothe the greatest pain and cause sleep. It is obtained by scratching the unripe capsules (fruit) with a small knife. The milky juice which comes out is allowed to dry and is then scraped off the capsule. In China this substance is smoked in a pipe for intoxicating purposes. The opium smoker soon sinks into a half conscious state in which pleasant dreams come to him. On waking up again he is, however, very dull, suffers from headache and so on; and in order to get rid of the discomfort he again indulges in a smoke. To take effect, after a time, the dose must be increased, and this slowly but surely undermines the health of the smoker until he sinks into an untimely grave.

1. The **Stem** and **Leaves** have a bluish coat of wax on them, which, as we have seen in the case of the Lotus plant, serves as a means of protection against the choking up of the little breathing holes (stomata) by rain water. The leaves near the root are larger than those higher up. If it were not so, the upper leaves would prevent the sunshine from falling on the lower ones and make them useless for making starch. The upper leaves also lie closer to the stem: this serves the same purpose. Besides, having the large leaves low down, the stem need not be so strong; and the leaves also afford shelter to the root and keep the soil there damper than if they grew at a height from the ground.

If the stem is wounded, a milky juice comes out. This dries and hardens and so protects the tender cells inside from further injury. The juice also gives the whole plant a peculiar smell and taste, which animals do not like and so prevents them from feeding on the leaves.

2. The **Flowers,** when in bud, have a calyx of two green sepals. These drop as soon as the flower opens, and the petals, which were crumpled up inside, open out and become quite smooth, and the flower with its four large, shining, white petals becomes very conspicuous. This plant, too, secretes no honey, but is visited by insects for the sake of the pollen which they eat and which is produced abundantly on the numerous stamens. Whilst eating they scatter the pollen dust about, covering themselves. The scattered pollen is caught by the large shell-shaped petals and kept ready for the next insect visitor. The upright position of the flower also helps to prevent the pollen from being spilt and wasted on the ground.

The petals are too weak to carry the weight of the heavy insects that come to visit the flower; another resting place is, therefore, provided, namely the broad rayed stigma that spreads over the ovary like a shield. The insects which have visited other poppies and got covered with pollen alight here and naturally drop some of the pollen-grains thus fertilising the ovules or future seeds in the ovary (fig. 4, 4).

3. If the **Fruit** is cut across (fig. 4, 3), the structure is easily seen. There are numerous walls inside, like the radii of a circle, which, however, do not quite join in the centre, and it is on these walls that the seeds grow until they are ripe when they drop off into the space between the walls. In order to let them escape from the capsule (as the fruit is called), little windows open all round the top just below the stigma (fig. 4, 5),

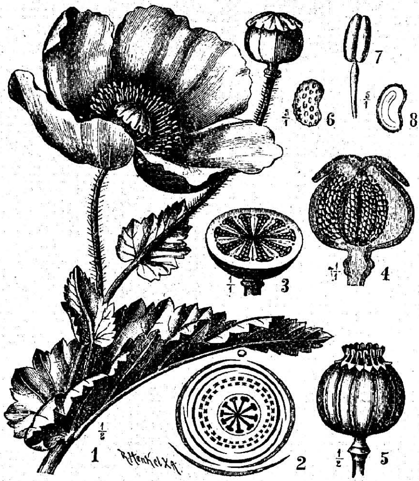

Fig. 4—1. Opium Poppy *(Papaver somniferum)*. 2. Diagram of flower. 3. Transverse and 4. vertical section of ovary. 5. Ripe capsule. 6. and 8. Seed. 7. Stamen.

and if the plant is shaken by the wind, the tiny seeds are thrown about in all directions. Bend down one of the ripe capsules and let it go, and you will see what happens. We now see also why the stalk is tall and springy, as the higher the seeds are from the ground the further will they be scattered.

Other Poppies.

The **Mexican Poppy** (*Argemone Mexicana*) is a well-known weed with prickly leaves and a yellow juice in all its parts. Oil for lamps is extracted from the seeds. The seeds are also used as a purgative.

Fig. 5.—Corn Poppy (*Papaver Rhœas*).

The **Corn Poppy** (*Papaver Rhœas*) is sometimes grown in gardens for its beautiful scarlet flowers. To the farmer the Corn Poppy is a pest, for it robs the corn of nourishment, light and space.

3. The Crucifer or Mustard Family.

(Cruciferæ.)

Herbs without milky juice. Flowers radial, with 4 sepals and 4 petals, arranged crosswise. Stamens 6, the two outer shorter, and the four inner longer. Ovary superior, formed of 2 carpels. Fruit a pod, divided into 2 valves by a central frame to which the seeds adhere.

The Indian Mustard (*Brassica juncea*).

(Compare Rape, Plate No. 625.)

(*Can.* Sāsive. *Mal.* Kaḍuka. *Tam.* Kaḍugu. *Tel.* Āvālu. *San.* Sarshapah, Raktajāji, Dundubha.)

If you bruise some Mustard seeds between two pieces of paper, a grease spot is left on the paper. This is due to the presence of a fatty oil in the seed. Some plants, like the Rose and "Tulasi", have another kind of oil in their leaves which does not cause a grease spot but vanishes quickly. This kind of oil is called a "volatile" oil and is generally the cause of the scent in flowers. The "fatty" oil serves as a food for the young seedling.

The Mustard seed has also a volatile oil which is very pungent and will cause tears to come to the eyes. It is this oil which protects the seed from being eaten by birds, and which makes the seed useful to us as a condiment or medicine, and it is for the oils in its seeds that the plant is so commonly grown.

1. The **Stem** grows to a height of 4 or 5 feet and spreads into many branches.

2. As in the Poppy, the **Leaves** gradually become smaller as they grow higher up the stem. In this case, though, the upper leaves have quite a different shape from those which grow at the bottom: the upper leaves have no stalks and are long-narrow and toothed, whereas the latter have long stalks and are lyrate, that is, are lobed and have the end lobe larger than the others. (The leaves of Rape are stem-clasping which those of Mustard are not; see Rape, Plate No. 625.)—The leaves, too, point upwards, and if you watch the rain falling on them or

pour water on them, you will see that the water is taken to the stem and runs down to the root.

3. The **Root** system of the Mustard plant, instead of spreading to a distance in all directions like that of, for instance, the Mango tree, forms a distinct tap-root with a few thin side-roots only. It is for this reason that in the Mustard plant the leaves carry the water to the centre of the root system.

4. The **Flowers** of the Mustard plant are bright yellow and have four sepals and four petals. The latter are stalked and grow inside but alternate with the sepals. There are six stamens, 2 with short filaments, and 4 (inside) with longer ones (fig. 6). The centre of the flower is formed by an ovary with a short style. If cut across (see diagram, fig.7), it can be seen that it is made of 2 carpels, the edges of which each bear a row of ovules.

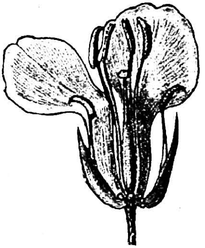

Fig. 6.—Flower of Mustard (*Brassica juncea*). One sepal and two petals are removed. (3 times natural size.)

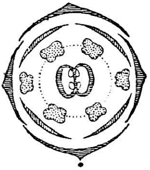

Fig. 7.—Diagram of a Crucifer flower.

The bright colour of the flowers, which open at the same time and in large numbers attracts the passing insects to look for the honey which is there at the base of the stamens. The insects pay for the kindness of the flower in providing them such a nice drink by spilling pollen on the stigma of the style and so fertilising the seeds.

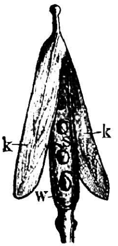

Fig. 8.—Silique of the Mustard plant. *k*. Carpels. *W*. Central frame. *S*. Seeds. (Natural size.)

5. The **Fruit** is a long erect pod formed of two dry carpels which split upwards and outwards from the base showing the seeds growing on a central frame (fig. 8). Such a pod is called a silique.

Other Crucifers.

The family to which the Mustard plant belongs contains a

very large number of plants in cool climates, but there are not many genera of this family in India. It takes its name from the crosswise arrangement of the different parts of the flower. Amongst representatives of the family we may mention the **Radish** (*Raphanus sativus,* Plate No. 625, 7. 8), the swollen root of which is eaten; the **Rape** or Coleseed (*Brassica napus,* Plate No. 625, 1 – 6), from the seeds of which oil is made, and **Cabbage** (*Brassica oleracea*) from which by cultivation all the varieties of cabbage, cauliflower and knolkohl have been produced.

4. The Mallow and Cotton Family.

(Malvaceæ.)

Herbs, shrubs, or trees, often with palmate leaves. Flowers radial, showy, with each 5 sepals and petals. Stamens many united into a tube or a column from the sides of which numerous filaments spring. Ovary superior, syncarpous.

The Indian Cotton (*Gossypium herbaceum*).

(Plate No. 629.)

(*Can.* Araḷe, Hatti. *Mal.* Karuparutti. *Tam.* Parutti. *Tel.* Patti. *San.* Kārpāsah.)

Several varieties of Cotton are cultivated in India, which are probably referable to 3 main species:—*a*) The Tree Cotton (*Gossypium arboreum*), *b*) the American Cotton (*G. Barbadense*), and *c*) the Herbaceous Cotton (*G. herbaceum*).

1. The Herbaceous Cotton is a perennial and bushy shrub in the warmer areas, and annual where the cold weather being severe kills the plants. The stems are erect, the branches spreading, and the leaves pale green, thick, leathery, half segmented into 3 or 5 or 7 broad lobes, and alternately arranged on the stem. In their axils the **Flower** buds grow and are protected not only by the calyx but also by three large heart-shaped bracts (Plate 629, 4). The five large petals are bright yellow, usually rendered more conspicuous by being coloured dark purple at their base. The numerous stamens, so combined with the petals that they form a tube covering the ovary and the style (fig. 9, 3), produce large quantities of yellow pollen-dust for the insects to feed on.

The long style grows through the tube, formed by the stamens, and bears five stigmas above everything else, and they are therefore in the best position to catch the pollen brought by insects from any other flower they have visited. Without pollen the fruit will not set, and the plant will not bear any seed.

2. The **Fruit** is a dry capsule (fig. 9,4) which divides into three parts, when ripe, showing the long white fibres in which the seed is protected (fig. 9, 5). These fibres are "cotton" and are intended to enable the wind to carry the seed to a distance. It is on account of these fibres that the plant is so largely cultivated in almost all tropical countries. The cotton is gathered by hand, dried in the sun, passed through a gin to remove the seeds and then pressed by machinery into very hard bales. The bales are sent to the mills, where the cotton is spun into thread and woven into cloth.

3. The cotton plant is also **useful** in various other respects. The stems of the plant yield a good fibre. The seeds (fig. 9, 6 and 7) are in many parts of India thrown away as a useless article. But they can be given to cattle, especially to milch cows, to increase the flow of their milk, for they contain an oil which is nourishing.

"The superior cottons belong to the *Gossypium arboreum,* and these should be cultivated more largely than the *G. herbaceum,* which is at present the staple of Indian produce" (Mukerji, *Handbook of Indian Agriculture*).

Other Mallows.

Many other Indian plants belong to this family, as the **"Ladies' Fingers"** (*Hibiscus esculentus*), the **Shoeflower** (*H. rosa-sinensis—Can.* Dāsaḷa; *Mal.* Čemparutti; *Tam.* Šembarttai; *San.* Japa, fig. 10), the **Portia Tree** (*Thespesia populnea—Can.* Huvarasi mara; *Mal.* Pūparutti; *Tam.* Pūvarašu; *San.* Kundaḥ), the **Red Silk Cotton Tree** (*Bombax malabaricum—Can.* Kempu būraga; *Mal.* Muḷḷilavụ; *Tam.* Ilavu; *San.* Pūraṇī), and the **White Silk Cotton Tree** (*Eriodendron anfractuosum—Can.* Biḷi būraga; *Mal.* Pūḷa). The garden shrub *H. schizopetalus* has hanging flowers with ciliated petals; in *H. mutabilis,* **Changeable Rose,** the flowers change from white to red in the course of the day; **Roselle** (*H. sabdariffa*) has a red fleshy calyx from which jelly is made.

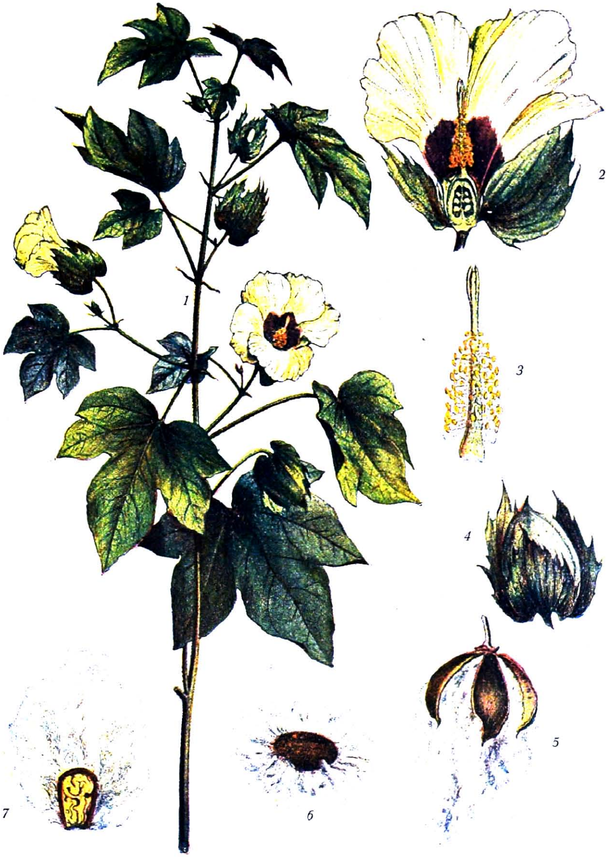

Fig. 9.—Herbaceous Cotton *(Gossypium herbaceum).*

2. Vertical section of flower. 3. Monadelphous stamens. 4. Unripe capsule. 5. Ripe capsule. 6. Seed. 7. Section of seed.

The "Ladies' Fingers" (*Hibiscus esculentus*).

(*Can.* Beṇḍekāyi. *Mal.* Veṇḍa. *Tam.* Veṇḍa. *Tel.* Beṇḍekāya. *San.* Pātali, Nētrāçc̄ōtana.)

An annual plant, cultivated for the fruit which is eaten as a vegetable.

1. The **Leaves** and all other parts of the plant are covered with bristles as a protection. The radical leaves (at the root of the plant) differ in some respects from those growing higher up. They are large, not lobed, and the long stalks hold them away from the stem; those growing on the stem are smaller, five-lobed, & more or less upright, forming an acute angle with the stem. The advantages that the plant derives from these differences are:

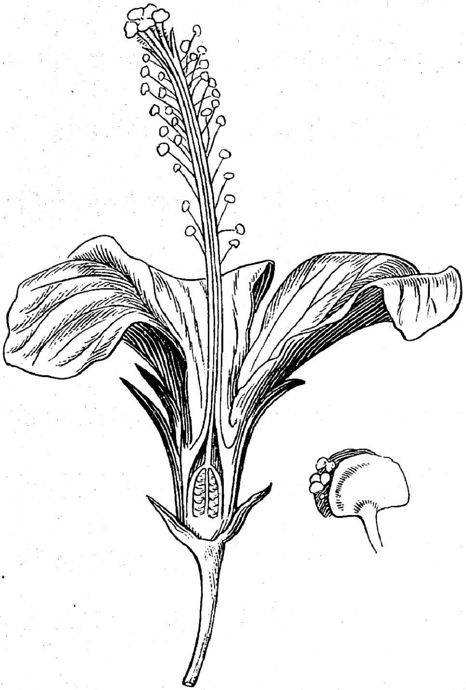

Fig. 10.—Longitudinal section of Shoeflower (*Hibiscus rosa-sinensis*). Natural size. To the right a single stamen.

a) The upper *and* the lower leaves get a fair share of sunlight, as the lower ones project further than the upper ones.

b) The smaller leaves, being above the roots and stem, have not to withstand so much pressure from the wind as they would have to, if they were as large as the radical leaves.

c) It is important for the plant to grow big leaves first, because they are able to make more starch, without which the rest of the stem could not be made.

2. The **Flowers** that rise out of the axils of the leaves are pale-yellow with a dark crimson centre. In the bud the petals are twisted, thus helping the calyx to protect the stamens and the ovary. The stamens are united as in the flower of the cotton plant, and similarly enclose with their column the ovary, which, after fertilisation, grows into a large capsule with from 5 to 8 partitions, filled with numerous seeds. Before they are ripe the capsules contain a slimy juice and are very nutritious.

3. When ripe, the **Capsule** splits from the tip in order to let the seeds escape. It would, however, be of little use if the seeds simply dropped, as the young plants would then all grow in a cluster at the place where the parent plant had grown and would be too close to one another to develop properly. They must, therefore, be scattered, and it is in order to make this easy that the capsules grow nearly vertically and on a tall stem; for the wind can then beat the capsules against the stem and the seeds get thrown out sideways.

Allied Families.

The **Chocolate Tree** (*Theobroma cacao,* Plate No. 627) belongs to the *Sterculiaceæ* which are nearly allied to the Cotton family. It was introduced into India from tropical America. Its gourdlike fruits contain, in their sour pulp, very bitter seeds, the so-called Cacao-beans (fig. 11, 3, 4). These are cleaned, husked, roasted, and powdered, and then become Cacao or Cocoa, which, mixed with sugar and flavoured with Vanilla, makes Chocolate.

Another allied Family are the *Tiliaceæ,* of which we mention the **Jute** (*Corchorus capsularis*). This shrub is largely cultivated in Bengal for its fibre which is manufactured into coarse fabrics, such as gunny-bags, the common coarse bags in which the various grains are sent to market.

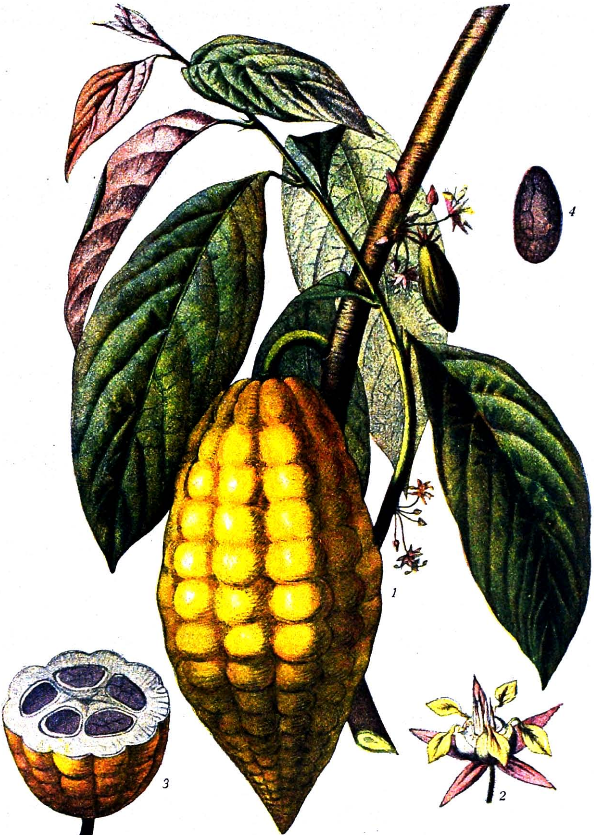

Fig. 11.—CHOCOLATE TREE (*Theobroma cacao*).

2. Flower. 3. Transverse section of fruit. 4. Seed.

5. The Tea Family.

(Ternstroemiaceæ.)

Trees or shrubs. Flowers radial. Sepals and petals each 5. Stamens multiples of 5. Ovary superior, of 3 carpels.

The Tea-shrub (*Camellia theifera*).

(Plate No. 624.)

(*Can.* Čāgiḍa. *Mal.* Čāyaččaḍi. *Tam.* Thay-ila.)

The Tea-shrub is found wild in the jungles of Assam, but is extensively grown on the slopes of the Himalayas, the Nilgiris, and in Ceylon. It has leathery, shining leaves of a dark-green colour with toothed edges which reflect the hot rays of the sun and thus keep the tree cool. It flowers all through the year and bears beautiful white flowers with 5 or more large petals and numerous yellow stamens, adhering partly to the base of the petals and partly to the ovary (Plate No. 624, 2. 3). When ripe, the woody capsule opens in such a way (Plate No. 624, 7) that each of the 3 carpels splits in the middle, thus letting the seeds escape.

Fig. 12. Flowering branch of the Tea-shrub (*Camellia theifera*).

The part from which the beverage "tea" is made are the leaf buds and the two or three young leaves next the buds. The volatile oil which is the cause of the flavour of tea and an alkaloid, called "theine", which has a soothing effect on the nerves, are contained in the leaf buds more than in any other part of

the plant. These leaves are picked carefully from the shrubs, partly dried in the sun or by machinery, rolled, and finally roasted to complete the drying. Of these dried leaves an infusion is made with boiling water, and this has the same flavour and odour as the tea leaves themselves; if allowed to stand for a long time, the infusion (tea) becomes spoiled, because a substance, called tannin, which is very astringent and is injurious to the digestion, is dissolved. Tea must, therefore, be drunk soon after the infusion is made.

Allied Families.

Allied families are the *Dipterocarpeæ* to which some very common trees of our forests belong; *viz.:* the **Sal Tree** (*Shorea robusta; Can.* Āsina mara; *Mal.* Sāla; *Tel.* Sālamu); the **White Dammar** (*Vateria indica; Can.* Dhūpada mara; *Mal.* Payannumaram; *Tam.* Veḷḷaikunnrikam); *Hopea parviflora* (*Can.* Bōvu; *Mal.* Irubōgam; *Tam.* Koṅgu); and *Hopea Wightiana* (*Can.* Karmara, Hiribōgi; *Mal.* Ilapoṅgu; *Tam.* Karam). In these trees (Vateria excepted) all or some of the lobes of the calyx enlarge after flowering and act as wings for the fruit. Hopea Wightiana is attacked by an insect producing in the axils of the leaves a fruit-like growth which contains the larva of that insect.

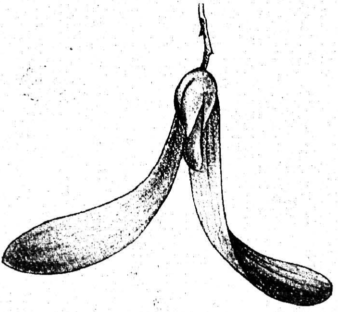

Fig. 13.—Winged fruit of *Hopea Wightiana*.

The *Guttiferæ* are another allied family, members of which are the **Pinnay Oil Tree** (*Calophyllum inophyllum; Can.* Surahonne; *Mal.* Ponnakam; *Tam.* Punnai), and *Garcinia indica* (*Can.* Puṇarahuḷi, Murginahuḷi; *Mal.* Punampuḷi).

Of the *Violaceæ* (Violet Family) we mention the pretty little *Ionidium suffruticosum* (*Can.* Purusharatna; *Mal.* Ōrilattāmara).

6. The Orange Family.

(Rutaceæ.)

Trees and shrubs, with alternate leaves dotted with transparent glands. Flowers radial. Sepals and petals 4 or 5. Stamens joined at their base into various groups. Ovary superior, syncarpous.

The Citron (*Citrus medica*).

(Plate No. 630.)

(*Can.* Mādavāḷa. *Mal.* Māduḷaṅgam. *Tam. Tel.* Mādiphalamu. *San.* Mātulaṅga.)

The fruit of this tree is a berry with about 10 divisions under the cover of a thick leathery skin which, in its outer part, contains numerous glands of aromatic oil (Plate No. 630. 3. 4). The pulp in which the few seeds lie is sour. The aromatic skin as well as the sour pulp are much prized.

The fruits grow in the leaf axils of evergreen shrubs or small trees. Their leaves are alternate and elliptical and have serrate edges. If you crush them, they smell strongly; for they are filled with that volatile oil which we have already noticed in the skin of the fruit. Hold a leaf up to the light, and you see its whole blade dotted with oil glands. The leaves are leathery and shining like those of the Mango tree.

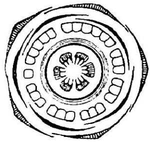

Fig. 14.— Floral diagram of Citrus.

The white and fragrant flowers consist of a cup-shaped, five-toothed calyx, a corolla with 2 fleshy petals which soon drop after unfolding, and numerous stamens whose broad filaments are joined into various bundles round the pistil (fig. 14).

From *Citrus medica* various varieties have been produced by cultivation, so the **Lemon** (*Citrus medica var. limonum*), the **Sweet Lime** (*C. med. var. limetta*), and the **Sour Lime** (*C. med. var. acida*).

Other plants belonging to this family are the **Orange** (*Citrus aurantium* — *Can.* Kittaḷe; *Tam. Mal. San.* Nāraṅgam), the

Pummelo (*C. decumana* — *Can.* Čakōtra, Sakkarekañji; *Mal.* Madhuranārakam), the **Bael Tree** (*Aegle marmelos*—*Can.* Belapatre; *Mal.* Kūvaḷam; *Tam.* Vilvam), and *Zanthoxylum Rhetsa* (*Can.* Jimmi, Kāvaṭe; *Mal.* Cuyiṭṭi).

Fig. 15.—The Orange tree (half size).

Allied Families.

There are various plants belonging to allied families which cannot be fully described here, but deserve a passing notice.

To the *Lineæ* belongs the common **Flax Plant** (*Linum usitatissimum* — *Can.* Atasi; *Tam.* Aḷiviral; *San.* Atasi). This is cultivated throughout India for the oil contained in its seeds (Linseed oil), and also for the fibres of its stem. The slender stems bear alternate, small leaves and pretty blue flowers, collected at the ends of the branches (fig. 16). The flowers are composed of 5 sepals, 5 petals, 5 stamens (united at their base), and 5 styles. The fruit is a round capsule, containing 2 oil-seeds in each of its 5 parts.

The fibres of the inner bark or liber of the stem are very tough and can, therefore, be used for textile fabrics. To get the fibres, the plants are first stripped of their seeds and then steeped in water until partially rotten, when the gummy part of the stem will be dissolved and the fibres loosened. Next, to separate the woody portion of the stem, they are spread to dry and then "broken", by which process the wood inside becomes brittle and breaks into pieces. The fibres are then drawn through a comb, called the hackle, where they are straightened and freed from dust and other matters. The fibre, which is thus

gained, has a fine, silky appearance, and is spun into yarn, and finally woven into linen cloth in the loom.

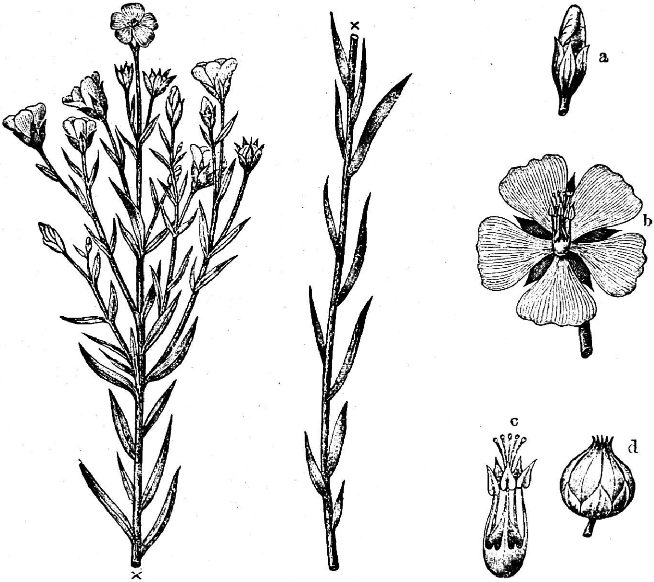

Fig. 16. Common Flax (*Linum usitatissimum*).
a. Flowerbud. *b.* Flower. *c.* Stamens and pistil. *d.* Ripe capsule.

Other plant fibres, generally used as material for clothing, are those of Cotton (which see, p. 11), Hemp, and Jute (p. 14). The fibres of many other plants are similarly used but only locally, as those of Sunn Hemp (*Crotalaria juncea*), American Aloe (*Agave americana*), Bowstring Hemp (*Sanseviera zeylanica*), Manilla Hemp (*Musa textilis*), etc.

To the *Geraniaceæ* belong the following:—

The **Bilimbi Tree** (*Averrhoa bilimbi*—*Can.* Bilimbi; *Mal.* Vilumbi; *Tam.* Pilimbi; *Hind.* Tamarung). It grows in the yards of many houses and bears plantain-like fruits on its trunk.

Its leaves are sensitive like those of many leguminous plants: they fold at night.

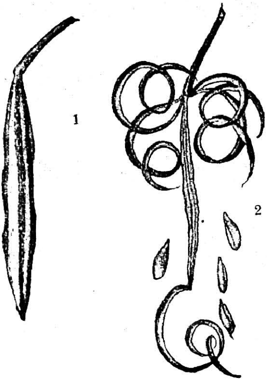

Fig. 17.—Capsule of a Balsam. 1. When closed. 2. Exploding.

The Garden **Balsam** (*Impatiens balsamina*—*Can.* Gauri-hū) is a very common plant during the monsoon, and its habits are characteristic of such plants as live in very moist places. The stalk and leaves are succulent, tender and covered with a bluish coat of wax (see page 6, 1). Under the tuft of leaves at the top the spurred pink flowers grow as under a protecting roof. If you pluck the pretty flowers for a bouquet, they very soon fade. As the plant grows at a time while, and in places where, water can be obtained plentifully, it is not furnished with those means which tend to check the evaporation of the sap in the plant so much required by plants living on dry soil (such as a thick epidermis, small leaf-blades, hairy surface, p. 47). So it cannot remain fresh without water and soon fades when plucked.—If we touch its ripe seed-vessels, they burst with great force and cast the seeds far away as by an elastic spring (fig. 17). The same happens, if the wind shakes the plants.

Fig. 18.—Branch of Grape Vine (*Vitis vinifera*) with grapes.

A very common tree, whose bark and leaves are in repute as medicines, is the **Neem** or **Margosa Tree** (*Melia indica*), also belonging to an allied order, the *Meliaceæ*.

Of the Vine Family (*Ampelideæ*) we mention

The **Grape Vine** (*Vitis vinifera*—*Can.* Drākshe). This is a weak shrub which, with the help of tendrils growing opposite the leaves, seeks support

on other plants and climbs up towards the light. It is cultivated in some parts of India and produces the sweet, juicy grapes which are praised as the best fruit of the whole vegetable kingdom. They are eaten fresh as dessert grapes, or dried as raisins. The chief use, however, of this plant is the wine made from the grape. For the preparation of wine the juice is first expressed. The sweet juice, thus obtained, soon becomes cloudy; for innumerable germs (bacteria) begin to work in it. These live in the soil of the vineyard and are blown by the wind on to the skin of the grapes, and thus come also into the juice of the grapes. Here they grow and reproduce themselves rapidly, and cause an important process in the liquid, called fermentation. Two new substances are formed in it, namely alcohol and carbonic acid gas which from time to time bursts in bubbles and escapes. By this process the sweet juice is gradually changed into alcoholic wine. This drink has a stimulating effect on the nerves, if taken in small quantities. Its abuse, however, is very injurious to the health and is the source of much misery. For children wine is always injurious, even if taken in very small quantities.—Another species of this genus is *Vitis quadrangularis* (*Can.* Sandubaḷḷi; *Mal.* Čaṅalamparanda; *Tam.* Ārugani; *Tel.* Vajravaḷḷi). It is common in hedges and, though a poor-looking and scraggy plant, is typical of the order. Its fleshy, cactus-like, jointed stems point to its habitat in dry regions.

7. The Mango Family.

(Anacardiaceæ.)

Trees or shrubs, often with milky or acrid juice. Sepals, petals, and stamens generally 4 or 5. Ovary superior. Fruit a drupe.

The Mango Tree (*Mangifera indica*).

(Plate No. 639.)

(*Can.* Māvu. *Mal.* Māvu. *Tam.* Mā. *Tel.* Māvi. *San.* Čūtah, Āmrah.)

This tree grows all over India and is not only one of her stateliest trees, but also produces one of her best fruits.

1. The **Trunk** of the tree is covered by a dark-grey, cracked bark, when old. The young plant has a green outer skin, called epidermis, such as annual herbs have. But as the tree grows larger, the epidermis, not being able to stretch, bursts. It is now necessary for the plant to form a new protective cover, which is done by constantly forming air-and water-tight layers of what are called *cork* cells. Some trees form a very thick layer of cork, like the Andipunar tree (*Carallia integerrima*), or the Spanish oak, the bark of which is the ordinary cork which is sold in shops. If the cork is thin, the stems have a smooth surface like the Guava, or the Jack tree. The Mango tree has a thick layer of cork which, as it thickens, cracks until flakes of bark drop off.

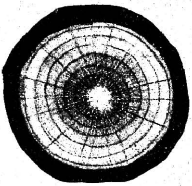

Fig. 19.—Transverse section of the stem of the Mango tree.

Under the cork layer is the *inner bark*, called *bast*, and inside this are concentric layers of wood. The younger or outer layers of wood are that part of the stem through which the sap ascends from the roots to the branches. Any injury to the bark or sapwood may interfere seriously with the circulation of the sap or let disease-fungi enter into the stem. A tree, however, has the power of healing its wounds by a rapid growth of cork at the edges which gradually cover the damaged area. This peculiarity is made use of in the process of grafting mangoes.

A small Mango plant, about as thick as one's finger, is grown from a seed in a pot, and when it is required to make a graft, a slice is taken out of one side of the stem down as deep as the pith and about an inch long. A branch of one of the good edible kinds of Mango of the same thickness is treated in the same way. The two trees are then so placed that the two cut parts of them are opposite one another. They are tied firmly together with some soft twine and covered over with cowdung. In a short time (a month to 6 weeks) the two cut surfaces unite, when the branch may be cut away altogether from the tree and the top from the seedling, and the graft Mango can be taken away and planted.

2. The **Leaves** are long and narrow. (*a*) They are *so placed* on the stem *as to allow each to get its share of light:* the result is that the Mango tree gives a very dense shade.

(*b*) The *petioles* (leaf-stalks), besides placing the leaves in such a position that they can get light, also *save them from being torn* when the *wind* blows very strongly as they are springy. If the leaves were fixed on more rigidly the branches of the tree would get broken. As it is, the leaf sways from side to side and so escapes most of the wind pressure. In a similar way, by bending down, they allow any raindrops falling on them to drop to the ground from their tapering ends, instead of adding to the weight the branches have to bear.—The leaf must, however, have a certain rigidity in order to spread out a wide, green surface to the sun, and this is obtained by the system of veins or ribs.

(*c*) The leaves are also *leathery*, due to a thick epidermis (coat), which *reduces the rate of evaporation* of the water in the tree and is, therefore, of great importance to it. Every one knows that the Mango tree is evergreen and able to keep its leaves on all the year round. It thus preserves its roots much cooler than a tree which has at times no leaves, like the Teak. It is also able to go on storing up food all through the year, and as its fruit forms at a time when most trees are leafless, this is another very great advantage to the Mango tree. But it does not follow from this that the Mango tree (or any other evergreen tree) has no resting period. "There is a definite periodicity—that is, a regular alternation of resting and working periods—noticeable in all tropical trees although the seasons at which episodes like the fall of leaves or the shooting of buds take place, vary greatly in different species, in different individuals of the same species, nay in different branches of one individual. In the Mango tree, for example, one or two branch systems may alone be putting forth the reddish-brown young leaves at a time when the rest of the crown retains the dark-green adult foliage" (J. M. F. Drummond).

(*d*) Further, the leaves are *smooth and shining* like a looking glass. Now, we all know that light-rays are reflected from the

surface of a mirror and not absorbed. The same is the case with the heat-rays which accompany the former, and by thus reflecting the heat-rays the temperature of the leaf is kept down and *a further source of evaporation taken away.* Evaporation increases in proportion as the temperature rises.

(*e*) The *young leaves* of the Mango tree are specially protected against any injury from excessive heat and light. When the tree is budding you can see all the young leaves *hang loosely* as if they were fading (fig. 20). They have grown at an enormous rate and attained the size of full-grown leaves in a very short time. This being so, the tender cells of which they are composed and their contents could be easily destroyed by a vigorous act of transpiration and consequent want of water. The vertical placement of these large but tender leaves reduces the effect of heat. When the leaves are mature, the tissues are strained, and the leaves assume the ordinary horizontal position.

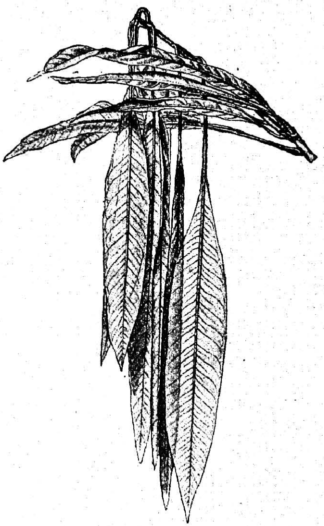

Fig. 20.—Young shoot of Mango with pendent leaves.

Young leaves are pendent also in the following common trees, the Cinnamon tree, the Chocolate tree, the White Dammar (*Vateria indica*, *Can.* Dhūpada mara) and *Hopea Wightiana* (*Can.* Karmara).

(*f*) The young leaves of the Mango tree are often *red* or *copper-coloured*. This is caused by a very active process of respiration or breathing, which, as we all know, is most active always in young organisms. For a plant, like an animal, breathes, that is to say, inhales oxygen in order to burn off some of its

carbon and thus produce the heat necessary for the various chemical processes carried on in its body to maintain its life and to grow. The gas produced by the combination of the inhaled oxygen and the carbon in the plant is carbonic acid gas, which is exhaled (see II. part, Respiration). When the leaves become older, the process of breathing becomes slower and the copper-hue disappears from the leaves, changing into the ordinary green colour of leaves. The colour is due to littte green granules, called chlorophyll * granules in the inner cells of the leaf. These granules have the power of feeding on the carbonic acid gas circulating through the air-spaces between the cells and to form starch under the influence of the sun's rays. This process is known as "assimilation" (see II. part, Assimilation).

(*g*) Another fact connected with the *arrangement of the leaves* may be noticed. They are so placed that, when rain falls, most of the water is carried from leaf to leaf *from the centre* of the tree *to its circumference* (compare the flow of water down a tiled roof!), and it is on the outside of the tree that the young roots which alone can absorb water are most numerous. The big roots cannot do so, as they are covered with bark. This dripping tends to make the young roots grow outwards to where they can get water easiest. This again serves to give the tree a very wide root system and prevents its being blown over by storms.

3. The **Flowers** are small and grow in erect panicles, which generally appear in January, February or March The 5 sepals enclose 5 greenish-yellow petals which are alternate with them. There are from 1 to 5 stamens,

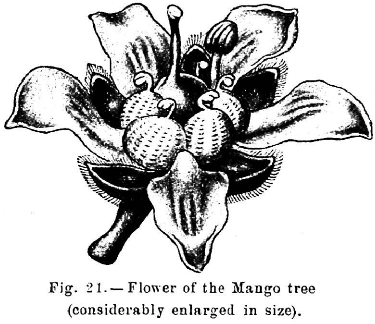

Fig. 21.—Flower of the Mango tree (considerably enlarged in size).

* From Greek *chloros*, green, and *phyllon*, a leaf.

one of which only is perfect. The flower contains, in addition, a nectary which is an organ to secrete honey. You find it arranged round the ovary and consisting of 5 fleshy bodies. The existence of such a nectary suggests that the flower depends for fertilization on attracting insects. The want of show in individual flowers is made up for by placing very large numbers of flowers close together.

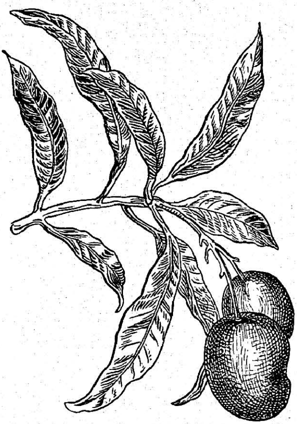

Fig. 22.—Branch of the Mango tree with fruits.

4. When the **Fruit** begins to grow, the stalk of the panicle is not strong enough to hold it erect, so the fruit hangs down. Even so it would never be able to nourish all the fruits which might be expected from the number of flowers. Nature corrects herself. As the fruits grow, nourishment is gradually directed into from one to six of the most vigorous fruits, and the rest drop off gradually.

The ripe fruit is slightly compressed and is beaked, the point showing where the style was. It contains a fleshy, palatable pulp under its leathery skin. The pulp surrounds a woody one-seeded nut with a fibrous beard. In the more inferior kinds these fibres run right through the pulp. The whole fruit is just a big drupe like a peach or plum.

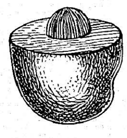

Fig. 23.—Transverse section of a Mango drupe with seed.

5. If the **Seed** is to grow into a new tree, it must be carried away from the tree which bore it, as it could not thrive under the dense shade of the parent tree. This is provided for by the delicious pulp covering the seed, attracting men and animals to pick it up and carry it away. The seed is protected at the same time by its hard covering.

We may notice a further instance of Nature's care in that the fruit, until it is ripe, is so acid that it cannot be eaten with any pleasure. Unripe seeds do not grow well.

6. **Enemies.**—The Mango tree has many enemies destroying its leaves and fruits. Especially the young leaves of the tree are subjected to the attack of various insects. In northern India the Mango Weevil (*Cryptorhynchus mangifera*) is a great pest. The larvæ of this beetle grow in the fruit, the eggs being deposited either on the ovary of the flower or on young fruits. As the hibernation of the insect through the winter months takes place in the bark of the tree, the crevices and holes in the trunk of the trees thus affected should be plastered over to destroy the insects at that time.

Other Mangoes.

The Mango tree has some relatives affording useful fruits. One of these is the **Cashew Nut** (*Anacardium occidentale – Can.* Gēru; *Mal.* Kaçumāvu; *Tam.* Mundirikai; *Tel.* Jīḍimāmiḍi; *San.* Çōphaharā), an American tree, brought to India by the Portuguese. What is generally called the fruit is the swollen flower stalk or receptacle which bears the seed in a hard case at the end. Both the juicy stalk and the nut are eaten. The former is very pretty, being coloured either a pale yellow or a brilliant red. The latter is protected by the cells in the cover being filled with an extremely acrid juice. They are, as a rule, roasted before being opened to get at the kernels which are edible and are exported in large quantities from the Malabar coast.

The **Indian Marking Nut** (*Semecarpus anacardium — Can.* Gērkāyi, kēra; *Mal.* Čermara; *Tam.* Çengoṭaimaram; *Tel.* Jiḍičeṭṭu; *San.* Agnimukhi) yields a corrosive black juice, used by dhobies for marking clothes.

The fruit of the **Hog Plum Tree** (*Spondias mangifera—Can.* Ambaṭa; *Mal.* Ambāḷam; *Tam.* Käṭṭumā; *Tel.* Ambāḷamu; *San.* Āmrātaka) is eaten, being a substitute for tamarind in curries. The tree flowers when it is leafless.

8. The Leguminosæ.

Trees, shrubs, or herbs. Leaves very often compound with stipules (leaf-like appendages at the base of the leaf-stalk). Flowers zygomorphic. Sepals 5, petals 5. Stamens generally 10, free or variously combined. Fruit a legume with the calyx attached. Ovary superior, of one carpel.

This large order is divided into three families:—

A. The Peaflower Family (*Papilionaceæ*).

B. The Cassia Family (*Cæsalpinieæ*).

C. The Mimosa Family (*Mimoseæ*).

A. THE PEAFLOWER FAMILY (*Papilionaceæ*).

The Garden Pea* (*Pisum sativum*).

(*Can.* Baṭāṇi. *Mal.* Pattāṇi. *Tam.* Paṭāṇi. *Tel.* Guṇḍuçanagalu.)

The Pea has from time immemorial been a plant cultivated by man for its nutritious seeds.

1. **Seed** and **Germination.**—If a few pea-seeds be laid in water or on moist earth, the coat of the seeds, called *testa,* can after a short time be easily torn off. The seed is then seen to consist of 2 halves, which represent the seed-leaves (fig. 24, *b*). Between these a small bud can be seen, in which root (radicle, fig. 24, *a*), stem and leaves (plumule, fig. 24, *c*) may easily be distinguished. The seed then contains under its coat the future plant in miniature. Considering how tender this bud is, we can understand why the outer coat is so hard and leathery: it has to protect the bud.

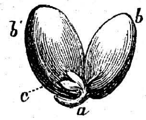

Fig. 24.—Seed of the Bean.
a. Radicle. *b*. Seed-leaves. *c*. Plumule.

To *observe the first stage of the growth of the plant, i. e., of its germination,* we put a few seeds in water. After some time they swell until the expanding germ bursts the coat and a tiny

* If the Pea is not at hand, any of the following will answer equally well as type of this tribe: Bean, Gram, Indigo (Plate No. 634), Wild Liquorice, or Shankapushpa (*Clitoria*).

root makes its appearance. If we now place the seeds in moist and loose earth, we shall find that the root forces its way downwards into the ground, gradually sending off tiny branches or rootlets all round. Then the stem above the seed-leaves begins to lengthen and to bend like a hook, making its way upwards until it reaches the surface, when it will, at last, become straight and unfold the first pair of leaves. The seed-leaves lie below the ground. As the stem continues to grow producing leaf after leaf, the seed-leaves at the bottom wither and fall off, because all the food stored in them has been absorbed.

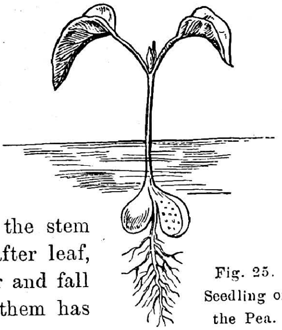

Fig. 25. Seedling of the Pea.

This process of germination gives us many things to learn.

(*a*) If peas or any other kind of seed are laid on a dry spot, they never germinate. They do so only when they are moistened. But then the question arises: why does the mother-plant not furnish the seeds with the water necessary for their germination at the very beginning, or why are the *seeds* always so *dry and hard* when they are produced in the fruit of the mother-plant? If it were not so, the seeds would try to grow as soon as they fall on the ground. But the tiny weak roots could not make their way into the hard ground, nor could they find any nourishment during the greater part of the year. For, at the time when plants generally ripen their seeds, the ground is dry and hard, the rains being over. The seeds that had thus already begun to germinate would simply die of thirst and it would be almost impossible for a plant to reproduce itself by seeds. In the case of annual herbs, such as Peas and Beans, etc., it would mean the extirpation of the genus in a very short time; for annual herbs are not able to live after flowering and fruiting. Another advantage of having hard, dry seeds is that animals, birds, and insects cannot destroy them so readily as they could if they were soft.

(*b*) We have noticed that *the first part* that comes out of the germinating seed *is the root.* There is a reason for this. The young plant must be fixed in the ground, while the hook-like stem breaks through the surface of it. The side roots, issuing from the main root, make the mooring so much the firmer. The wind may now blow in whatever direction it will, it cannot overturn the plant.—The root has also other work to do. It must take in water and nourishment which is to be conveyed to the leaves where it will be transformed into that condition in which it can be used by the plant for the building up of new leaves. Now, the root must necessarily grow before any other part can do so. For then it will be ready for its functions and can at once send up food to the leaves when they are formed.

(*c*) The bud being extremely tender would suffer injury, if it had to force its way up through the soil. It is therefore that the thick, strong *stem bends* in such a way that the bud remains below whilst it raises the earth above it.

(*d*) All the parts of the germinating seed are entirely colourless so long as they are within the coat of the seed and below the surface of the earth. They become, however, green when they come up to the light. It is the *action of sunlight which produces the green colour* in the stems and leaves of the plants.

(*e*) We know that the plants build up new parts from the food prepared in the leaves. But whence does tbe germinating seed take the materials necessary to form the root, the stem, and the leaves, as it has no leaves to prepare its food? We shall be in a position to give an answer to this question when we examine the seed-leaves carefully. These leaves are hard and full in the beginning, but gradually they become softer and softer, until they finally shrivel up and decay: The plant grew and *formed its root, its stem, and the first pair of leaves, all at the expense of the seed-leaves*. These were packed full with provisions such as the young plant would require at its first stage of growth. This food is, in the case of the Pea and many other plants, deposited in the seed-leaves themselves, whereas we find the food-store separate from the seed-leaves in the seeds of Rice and many other plants.

The food, too, may be stored either as starch, as is the case in the Leguminosæ and the Grasses which include Wheat, Barley, Rice and Bamboos, or as oil which is the form the stored food takes in the Castor-oil plant, Flax, Cotton, Mustard and many others.

2. **The Pea plant as a Creeper.**—(*a*) The Pea plant is a *creeper;* for the slender stem, with its many leaves, is not able to stand upright and must needs seek the support of other stronger plants. For this purpose it is furnished with tendrils at the end of its leaves which take hold of any objects near them (fig. 26).

Fig. 26.—Pinnate leaf of the Pea with stipules and tendrils.

(*b*) The leaves are compound, each consisting of several pairs of leaflets arranged on opposite sides of the common stalk. Such leaves have some resemblance to a feather and are therefore called *pinnate* (like a feather). The *tendrils* at the end are simply the midribs of leaflets the blades of which have shrunk. They are straight at first, but when they strike a branch or twig of another plant or some other support, they coil round the latter, taking a firm hold. This done, the free part coils spirally, thus forming an elastic attachment to its support.

(*c*) At the base of the leaf-stalk there are large appendages, called *stipules* (fig. 26). They are, at first, placed vertically and protect the tender leaf- and flower-buds within them. At a later stage they spread out and expose their whole surface to the action of the sunlight, as they have exactly the same functions as the leaves themselves.

3. **The Pea plant gathering Nitrogen from the Air.**—If you carefully pull a Pea plant out of the soil, you will notice numerous

little knots or *nodules on the roots* (fig. 27) which are not accidental, but have their own little functions in the great household of Nature.

Fig. 27.—Root of Pea with nodules or tubercles (natural size). *Z.* Cell a of tubercle filled with innumerable bacteria (120 times enlarged). *B.* Bacteria (800 times enlarged).

In each little grain of earth there are numerous minute germs, called bacteria. Some of these have the peculiarity of settling on the tiny root-ends of the plants of this order and grow as parasites on them being nourished by their juices. They cause those parts of the root on which they settle to grow exuberantly, thus forming little nodules or tubercles (fig. 27, *Z* and *B*) on the roots. Now, these bacteria which are themselves tiny plants have the power, unlike other plants, of taking in from the air nitrogen which is an essential ingredient of the living parts of plants and without which plants cannot thrive. Other plants cannot take nitrogen from the air which, indeed, always contains plenty of it, but must take it from the soil through their roots. These bacteria, then, take their supply of nitrogen from the air. When they die after some time, their remains serve the Pea plant as very good manure containing, as they do, plenty of nitrogen. We see here, then, a beautiful reciprocity. At first the Pea plants allow the bacteria to settle on them and to participate in the food they draw from the soil and air for themselves. The guest in return gives nitrogen to the host.

This fact is of the *greatest importance to agriculture.* With each crop the farmer takes away from the field a great quantity of nitrogen deposited in the seeds and other parts of the crop, and this nitrogen has all been taken from the soil. If he wants another good crop next year, he must needs replace what he has taken away, and this he does in the shape of manure. If he also grows such plants as Gram, Lentils, Peas, etc. in the cropped fields, these themselves will help to manure the soil by acting as hosts to the bacteria which absorb nitrogen from the air.

Fig. 28.—Butterfly flower of the Pea.
a. Calyx. *b.* Standard. *c.* Wings. *d.* Keel.

4. The **Flower** has some **resemblance to a butterfly** (fig. 28). It is irregular but a vertical section divides it into similar halves.

(*a*) The *corolla*, supported by a cup-like calyx with 5 lobes, consists of 5 petals which are generally white and differ each in shape and size. The largest of them is erect and is called the *standard* (fig. 29, *St.*), because it stands up above the rest and shows its colours so boldly. It might also be called "sail", for it answers the purpose of one. The wind blows it round, so that it always turns its back to bad weather, and serves as a shield to the delicate parts within. The two lateral petals (fig. 29, *W.*) are called *wings,* and the two lower ones (fig. 29, *K.*) are so combined that they form a boat and are called the *keel.* These boat-like leaves enclose the stamens and the pistil (fig. 30), which latter consists of a long ovary and a style. The end of the style is bearded with a row of short hairs along its inner face and thus looks like a small brush (fig. 30, *S.*).

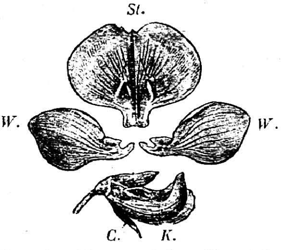

Fig. 29.—Flower of Pea dissected into its various parts: *St.* Standard. *W.* Wings. *K.* Keel. *C.* Calyx of which the front part is removed.

(*b*) There are 10 *stamens.* The filaments of 9 of them are united to a tube which, however, is not joined at the top. The filament of the 10th stamen lies in the split. It is only through this split that insects, attracted by the large standard and also by the sweet scent the flower exhales, can get at the honey which lies hidden within the tube of the filaments. While trying to get at the inner parts of the flower they must press down the keel. At once the style protrudes and touches the body of the visitor, which probably has come from another flower where its hairy body was covered with pollen, and the ovules are fertilized. Next, the brush under the stigma of the style, on which the stamens have deposited their pollen, rubs against the insect and sends it off to the next flower with a new load of dust. Now, as the wings and the keel of the flower are by a sort of joint at their base attached to one another very closely and firmly, it requires considerable strength to press them down so as to get at the honey in the interior. Not all insects have the strength necessary to do this. Bees are strong enough to overcome all the difficulties on their way to the honey, and it is chiefly by them that the Pea flowers are fertilized. Some of them, it is true, try to get at the honey by a shorter way. They break in like thieves and bite a hole through the flower-leaves at the base.

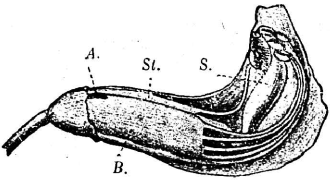

Fig. 30.—Keel of Pea flower (3 times enlarged). *B.* Bundle of the 9 combined stamens (only 4 of the 9 are visible). *St.* Single stamen. *A.* Access to honey. *S.* Style with stigma and brush.

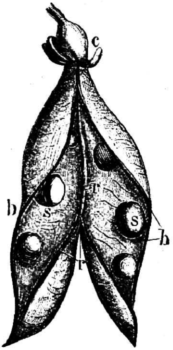

Fig. 31.—Legume of the Pea. *c.* Calyx. *s.* Seeds. *r.* Midrib. *b.* Ventral suture.

5. The **Fruit** (fig. 31) is a pod or *legume,* consisting of a single leaf, which is folded inwards in its midrib having the edges seamed together. It contains several seeds in one row, all

attached to the 2 edges of the seam of the fruit-leaf. When ripe, the legume splits both at the midrib as also at the seam, thus dividing into 2 halves. (Contrast the legume with the silique of the Mustard!)

Other Papilionaceæ or Butterfly-flower Plants.

1. **Usefulness.**—This tribe is a very large one. We find these plants cultivated in the fields for the fibre of the stem like the **Sunn Hemp** (*Crotalaria juncea; Can.* Saṇabu; *Mal.* Čaṇaka; *Tam.* Čaṇal), for their nutritious seeds like the **Bean** (*Phaseolus trilobus; Can.* Āvare: *Mal.* Čeruviḍukōl; *Tam.* Elippayaru), the **Horse Gram** (*Dolichos biflorus*; *Can.* Huruḷi; *Mal., Tam.* Koḷḷu), the **Bengal Gram** (*Cicer arietinum*; *Can.* Kaḍale; *Mal.* Kaṭala), the **Green Gram** (*Phaseolus mungo; Can.* Uddu; *Mal.* Uḷunnu; *Tam.* Uḷundu), the **Ground Nut** (*Arachis hypogæa; Can.* Nelakaḍale; *Mal.* Nelakaḍalaka; *Tam.* Vērkaḍalai), for the dye obtained from the leaves, like the **Indigo plant** (*Indigofera tinctoria; Can.* Nīli; *Mal.* Avari—Plate No. 634). But we can also see them wild in the forests, as for instance the **Rosewood** (*Dalbergia latifolia*; *Can.* Biṭi; *Mal.* Vīṭṭi; *Tam.* Iṭṭi), which yields an excellent timber, or the **Coral Tree** (*Erythrina indica; Can.* Hoṅgara; *Mal.* Muḷḷumurika), with its beautiful shining red flowers, and so many others; while the creepers **Wild Liquorice** (*Abrus precatorius; Can.* Gurguñji; *Mal.* Guñja; *Tam.* Kunri). and **Shankapushpa** (*Clitoria ternatea; Can., Mal.* Šaṅkhapushpa) adorn our hedges with the pretty scarlet seeds of the former and the large blue and white flowers of the latter.

2. Their **Leaves** are almost always *compound*, sometimes *trifoliate, i. e.*,consisting of 3 leaflets (Bean), sometimes *pinnate* having several leaflets attached to each side of the midrib generally with a single one at the tip (Indigo). In many cases the leaves assume *different positions during days and nights*, a peculiarity that deserves our particular notice. We take, for instance, the leaf of the Bean or of the Coral tree. It is trifoliate, the leaflet standing at the end being symmetrical and the 2 lateral ones oblique. In the day-time they are spread out to catch as much sunlight as possible (fig. 32, I); but as soon as darkness sets in,

the common stalk of the 3 leaflets begins to rise up, and the 3 leaflets descend and hang down vertically (fig. 32, II.). We say, the leaf "sleeps" now. On the following morning it resumes its original position. These movements, which are very regular, are effected by the swollen joints, which can be observed at the base of the common leaf stalk, as also on each of the stalks of the 3 leaflets.

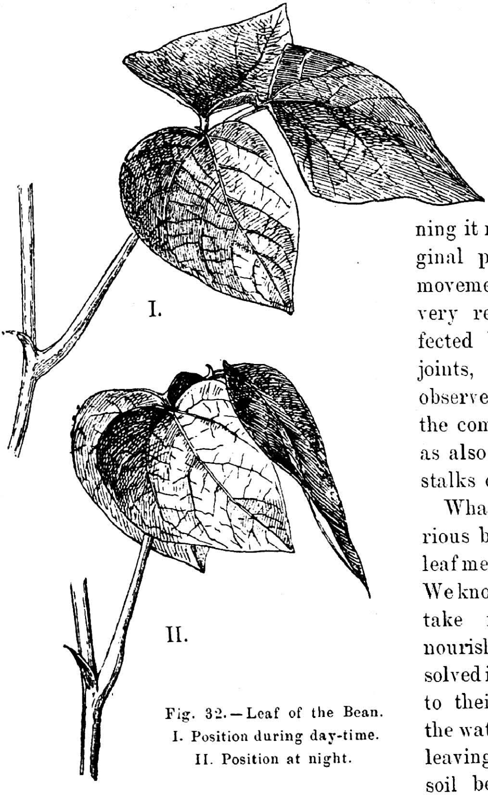

Fig. 32.—Leaf of the Bean.
I. Position during day-time.
II. Position at night.

What does this curious behaviour of the leaf mean for the plant? We know that the plants take from the soil nourishment which, dissolved in water, ascends to their leaves, where the water is evaporated leaving the salts of the soil behind it in the leaves. The work of thus pumping up new food to the leaves must stop when the evaporation by the leaves is obstructed; and this is exactly what takes place when dew settles upon the leaves. Now, it is a known fact that articles laid horizontally on the ground have a greater deposit of dew than such as hang vertically. The leaves, therefore, assume this position in order to prevent the dew from covering them and thus obstructing the

process of evaporation which is so essential for their growth.—Sometimes when the heat of the sun becomes excessive so as to cause too much water to be evaporated, they are also seen to assume their "sleeping" attitude. As they place themselves parallel to the sun's rays, they are struck only by a few of them and at oblique angles (fig. 34); consequently they do not get so hot as would be the case, if they were at right angles to them. This is another striking protective arrangement.

3. Many of the Papilionaceæ are **Climbers**, that is, their stems are so thin and weak that they cannot stand upright with the load of their leaves and flowers or fruits, but must seek some support to reach the light. Now, there are many plants that do this by means of tendrils, such as the Pea, the Gourd and the Vine, or by their thorns like the Rose. The majority of the climbing Papilionaceæ are, however, twiners. To understand the manner in which they twine, we shall examine some young plants of the Bean or of Shankapushpa (*Clitoria*) sown in flower-pots. In the beginning their stems will grow straight up; but then their tips bend and begin to make a circular movement finishing one turn in about two hours. The stem seeks a support. When it has found one, it turns round this firmly and the tip of the stem continues its circular movements as it grows and thus winds round and round its support. This movement of the stem of the Bean is made in a direction contrary to that of the hands of a clock, namely from right to left. There are other plants that move in the same direction as the clock's hands.

4. The **Flowers** are butterfly-like, as described in the Pea plant (fig. 28), and can be well studied in the Indian Coral Tree (*Erythrina indica—Can.* Hongara), or in the Dhak Tree (*Butea frondosa—Can.* Muttala). The largest butterfly-flowers are found on the tree *Sesbania grandiflora* (*Can.* Agase; *Mal.* Agatti). The parts of the flower are not grouped like the radii of a circle as was the case with most flowers we have studied heretofore. They form 2 symmetrical halves. We call such flowers zygomorphic (from greek *zygon*, yoke, and *morphe*, shape).

5. The **Fruit** is always a dry legume, originating of one fruit-leaf (carpel) and containing one row of seeds.

B. THE CASSIA FAMILY (*Cæsalpinieæ*).

The **Indian Laburnum** or the **Pudding Pipe Tree** (*Cassia fistula*—*Can.* Konde; *Mal.* Konne; *Tam.* Kovrai; *Tel.* Rēlačeṭṭu; *San.* Suvarnaka) is one of the most beautiful jungle trees when in full flower. The fragrant, golden flowers hanging down in long, drooping racemes appear after the first rains together with the pinnate leaves which the tree sheds in the cold season. The flowers (fig. 33) are slightly irregular, one of the petals reminding one of the standard of the butterfly-flower. The stamens number 10, they are all free and of various length. The fruit is a long, brown cylindrical pod or legume, the seeds being surrounded by a sweet pulp.

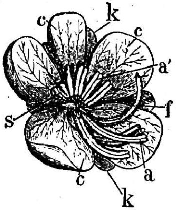

Fig. 33. — Flower of Cassia. *k.* Calyx. *c.* Corolla. *a.* Stamens. *a'.* The interior shorter stamens. *f.* Pistil.

Some other Cæsalpinieæ are the useful **Tamarind Tree** (*Tamarindus indica*—*Can.* Huṇise), the superb **Flower Fence** (*Cæsalpinia pulcherrima*—*Can.* Ratnagandhi), and the stout **Goldmohur Tree** (*Poinciana regia*—*Can.* Doḍḍa Ratnagandhi or Sankēšvara), called by the French in the West Indies "*Fleur de Paradis*". (Fig. 37.)

C. THE MIMOSA FAMILY (*Mimoseæ*).

The Babul Acacia (*Acacia arabica*).

(Plate No. 628.)

(*Can.* Karijāli. *Mal.* Karuvēlam. *Tam.* Karuvēl. *Tel.* Nallatumma. *San.* Barbūrah.)

This well-known tree is essentially a tree of dry regions and can, therefore, be met with more in the interior of India than on the sea-coast. To such places it is ingeniously adapted.

1. **Leaves** with large blades would allow too active an evaporation for the thirsty places the Acacia lives in. Their surface is, therefore, broken up into numerous linear segments; the leaves are *bipinnate* (= doubly pinnate). They possess also the ability of *folding their leaflets* (*cf.* Bean, p. 36). They do this

not only at night, but also in the day-time when the heat of the sunshine becomes excessive. By placing the leaflets vertically they cause the sun's rays to fall on them in acute angles and so reduce the heating effect of the sunshine and thereby the action of evaporation through their surface.

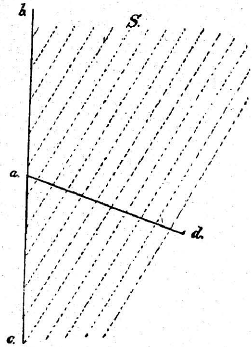

Fig. 34.—Solar rays falling vertically on *a d.*, but slanting on *a c*, which are both of the same length.

2. The stipules at the base of each leaf are transformed into *thorns* which the shrub can very well employ as weapons against animals which would otherwise feed on them. Protection is also afforded by an *astringent acid*, called tannin, contained *in the bark.* If the bark is damaged, gum trickles out of it and covers the wound. As the Acacia tree is one of the few plants that grow in deserts, it can very well make use of such means of defence.

3. The **Flowers** (fig. 35) are small, but are grouped in round heads. As the tree flowers in desert regions and at such a time when it does not rain, it can dispense with the many arrangements by which, in other plants, the pollen of the stamens is protected against bad weather. So the floral envelopes (calyx and corolla) are considerably reduced (see fig. 35, *c* and *k*), and the numerous stamens protrude widely from them. In fact the flower-heads look yellow from the pollen only.

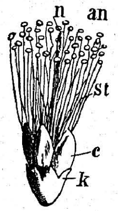

Fig. 35. —Flower of the Acacia. *k*. Calyx. *c*. Corolla. *st*. Stamens. *an*. Anthers. *n*. Stigma of style.

The *legumes* (Plate No. 628, 4) are flat and narrow and depressed between the seeds.

4. **Uses for man.**—The tree is useful in many ways. The wood is very hard and can be employed for all purposes for which a hard wood is required, such as plough-shares, knees and ribs of country boats, naves of wheels and so on. The bark is employed in tanning. The pods form a valuable food for

cattle, and the young branches are a favourite food of camels and goats. The bark yields also gum which is an article of general commerce.

Other Mimoseæ

are the **Red-wood Tree** (*Adenanthera pavonina*—*Can.* Mañjeṭṭi, Mañjāḍi) known for its scarlet seeds, the **Soapnut Acacia** (*Acacia concinna*—*Can.* Sīge), and the well-known **Sensitive Plant** (*Mimosa pudica*—*Can.* Nāčike-giḍa), so called from its highly sensitive leaves which fold and bend when touched (fig. 36). "The Sensitive Plants derive protective advantages from

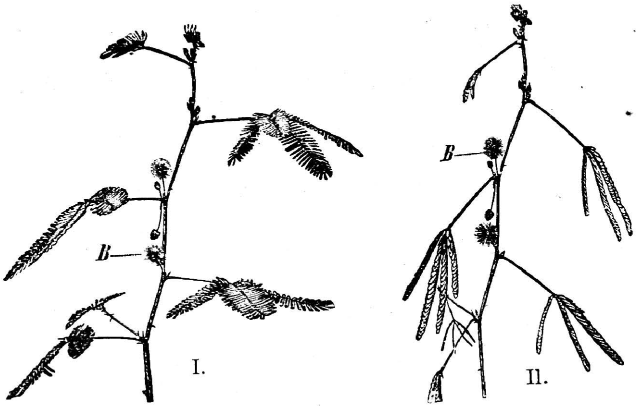

Fig. 36.—Mimosa pudica. I. Position at day, or when circumstances are favourable. II. Position at night, or when touched.

these movements. They often cover large tracts of land, and grazing animals may be often attracted towards them by their bright green foliage. But what happens? The very first plants the animal approaches droop their tempting leaves, sensitive even to the vibration of the ground caused by its approach; and should it step in amongst them, the tempting and juicy foliage recedes before it, for one plant conveys the shock to its neighbours by the touch of its own leaves as they drop. Thus, what

was a moment before a mass of tempting green leaves becomes almost instantly in appearance very scrubby fare for the animal, whose appetite anticipated much better refreshment. The stems are protected with strong and sharp spines. And now, when they have turned down their leaves out of harm's way, they present to their enemy for its first nibble nothing but prickly stems, so that should the intruder not be awed by their uncanny movements, but proceed with its intention, its first mouthful would scarcely be agreeable after its richer anticipations" (*Strand Magazine*, February 1908).

Various trees of this group form the characteristic flora of desert regions. Some of them have a peculiar mode of growth. Their *crown* is not round like that of the Mango tree, but *flat like a palm-leaf umbrella* (čatra, fig. 37). It is thus, indeed, more exposed to the sun's rays, but it presents its edges to the

Fig. 37.—An "umbrella tree". *(Poinciana regia).*

scorching winds instead of a large surface and thereby is better protected from loss of moisture by transpiration. The effect of the sun's rays is lessened by the trees' power of folding their leaves.

9. The Rose Family.

(Rosaceæ.)

Trees, shrubs, or herbs. Leaves alternate with stipules. Flowers radial, 5 sepals, 5 petals, and numerous stamens. Ovary free, or adherent to the receptacle, apocarpous, *i. e.*, having the carpels disunited.

The Rose (*Rosa centifolia*).

(*Can.* Gulābi. *Mal.* Paninīrpu.)

The Rose is the queen of flowers. Its graceful shape, the beautiful colour, and the delicious scent have won fame for it. It is the symbol of youth, of innocence and of beauty. With roses we decorate our houses on joyful occasions, and roses we lay on the graves of our beloved ones.

1. The **Double Rose** (*Rosa centifolia*) is cultivated in our gardens. If a bush with double flowers is not attended to and pruned and manured, it will in course of time yield single flowers. One of the species with single flowers is the Hedge Rose (*Rosa canina*) which in colder climates grows wild in hedges.

2. One of the remarkable things regarding the **Stem** are the *prickles*. They are sharp and bend slightly downwards. With the help of them the weak stems seek support on other plants that are stronger than themselves. But the prickles are also powerful weapons against enemies, such as cattle which would feed on them, or snails which would crawl up to the tender leaves, or mice which would eat the sweet fruits, called hips. It may be noticed that the prickles of the Rose are only loosely fixed on the bark and, therefore, differ from the spines of the Bael tree or the Lemon tree which are joined to the wood of the tree and are covered with bark and are, therefore, really branches.

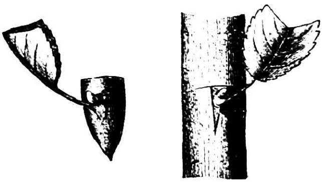

Fig. 38.—Grafting by budding.

As in the Mango tree the finer sorts of Roses are *grafted* on the wild sorts by budding, *i. e.*, by inserting the bud of a superior kind under the bark of the inferior (fig.38).

3. The Rose **Leaves** consist of a long middle rib with 5 or 7 leaflets, of which 2 are always opposite, the midrib ending in a single leaf. Such leaves are called *imparipinnate,* that is, unevenly pinnate (compare it with a feather!). At the base of the leaf-stalk are 2 *stipules* (leafy appendages) the object of which can be easily learned when we examine young branches: the stipules of an old leaf embrace a younger leaf; between the stipules of this, the next younger again is covered and so on. In this manner the inner, very tender leaves are covered by the outer ones by their sheathing stipules. The young leaflets are folded and laid together like the leaves of a book. It may also be noticed that the young leaves of some sorts of Roses are red coloured. (See Mango, page 24.)

4. In the **Flowers** of the Hedge Rose (fig. 39) we can distinguish first a green cuplike receptacle, containing numerous pistils and crowned by 5 calyx leaves, 5 petals and numerous stamens. The cultivated Rose has, however, numerous petals, which are formed by the transformation of some of the stamens. This is sometimes easily seen as some of the petals in the middle occasionally bear pollen bags. In the bud the sepals and petals are so arranged that they overlap one another by one

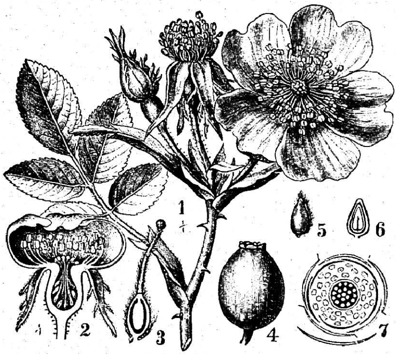

Fig. 39.—Hedge Rose (*Rosa canina*).
1. Flowering branch. 2. Longitudinal section of bud. 3. Ovule with style. 4. Hip (fruit). 5. and 6. Seed. 7. Diagram.

margin (fig. 39, 2 and 7), thus affording a very good protection from rain, damp and other damage.

5. The **Seeds** are seated in the hollowed-out fleshy top of the flower-stalk which becomes a beautiful red colour when ripe, and is made up of a soft sweet pulp in order to attract birds by whose means the seeds can be scattered far and wide. To prevent the seeds being digested by the birds they have a hard thick skin and prickly hairs and so are not damaged even if swallowed, which is rather unlikely, as the birds do not like the hairs.

6. The **Scent** of the Rose is derived from a volatile oil which evaporates easily and leaves no greasy stain, if applied to paper. This oil is extracted from the petals, by distillation, and then sold as a precious perfume, known as Attar of Roses.

7. **Enemies.**—The Rose shrubs are subjected to the attacks of various insects. The cockchafers defoliate the bushes, and several plant-lice (*Aphides*) and scale-insects (*Coccidæ*) prey on the juice of the stem and the leaves. What makes these garden pests so destructive is the rapid rate of their multiplication. A remedy suggested is the application of kerosine emulsion, prepared of one part kerosine oil mixed with 80 parts of water and this added to an equal quantity of fresh milk, all thoroughly shaken up in a bottle (*Agriculture,* Mukerji).

The Rose family (*Rosaceæ*) is but little represented on the plains of India. Many fruits, such as the Apple, the Pear, the Almond, the Peach, the Cherry, the Plum, Strawberries and Raspberries belong to this family, but come to prefection only in cooler climates.

10. The Myrtle Family.

(Myrtaceæ.)

Trees or shrubs. Leaves opposite, simple, entire, often with glandular dots. Flowers radial, stamens indefinite, ovary inferior. Fruit a drupe or a capsule.

1. The **Jamoon** (*Eugenia jambolana*—*Can.* Nērale; *Mal., Tam.* Nāval; *Tel.* Nērẹdu; *San.* Jāmbavam) is common every-

where in India, every soil and situation suiting it equally well. The violet fruits are eaten, when ripe, by men, animals and birds, and the seeds are scattered in this way. The bark is strongly astringent, and a decoction of it is used by native physicians. It can also be used for tanning fishing nets.

The tree has opposite, oblong, entire leaves with veins running into a nerve parallel to the margin. When held up to the light, we can see transparent dots in them, the dots being marks of a volatile oil (compare Citron, page 17). From the axils of the fallen leaves there grow panicles of small white flowers. The 4 petals which are inserted on a disc within the calyx, are thrown off when the flower-bud opens and the stamens unfold. Nevertheless the flowers remain showy on account of the great number, colour and length of the stamens (compare the flowers of Acacia, page 39). The inferior ovary adheres to the cup-like receptacle, ripening with the latter into a succulent drupe crowned with the calyx.

2. **Other Myrtles.**—*Myrtus communis,* the **Bridal Myrtle,** also found in Indian gardens, is the only European specimen of this family which is so largely represented in tropical countries. Several species of the genus *Eugenia* are pretty common in our country; such as the shrub *E. caryophyllæa* (*Can.* Kuṇṭāla; *Mal.* Nēral) yielding a very good fuel-wood; the shrub *E. zeylanica* (*Can.* Guḍḍapannēraḷu) with very aromatic leaves; and the trees *E. Jambos* and *E. Malaccensis* (*Can.* Kempu-jambuṇēraḷu; *San.* Jambu) yielding the Rose Apples. The **Guava** (*Psidium guava—Can.* Pēraḷe; *Mal.* Malampēra; *Tam.* Koyyāpaḷam; *Tel.* Jāmapaṇḍu; *San.* Pērāḷa) is largely cultivated for its delicious berries. **Cloves** are the dried unopened flowerbuds of *Caryophyllus aromaticus* (fig. 40). "Flowers worthy of Paradise, which Nature boon poured forth profuse" (Milton),

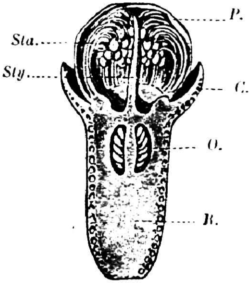

Fig 40.—Flower-bud of the Clove (*Caryophyllus aromaticus*). *R.* Receptacle. *O.* Ovary. *C.* Calyx. *P.* Petals. *Sta.* Stamens. *Sty.* Style.

adorn the tree *Barringtonia racemosa* (*Can.* Samudraphala). Of similar beauty are the large white flowers of *Careya arborea* (*Can.* Daddāla; *Mal.* Pīlam; *Tam., Tel.* Kumbi). We have still to mention the **Pomegranate** (*Punica granatum*—*Can.* Dāḷimbe; *Mal.* Tāḷimādaḷam; *Tam.* Mādaḷai; *San.* Dāḷika) which is cultivated in gardens almost everywhere in India, and the gigantic and useful **Blue Gum Tree** (*Eucalyptus globulus*—*Can.* Teiladamara), the leaves of which are so beautifully adapted to a dry and hot climate like that of its original home, Australia.

3. **Allied Families.**—Such are the *Melastomaceæ*, of which we mention two handsome shrubs, *viz.*, *Melastoma malabathricum* (*Can.* Doḍḍa-nekkare; *Mal.* Kaḍaḷi) with three-nerved leaves and curiously jointed stamens,—and *Memecylon edule* (*Can.* Aḷamar, Muṇḍi; *Mal.* Kāyāvu̥; *Tam.* Kāyā) which, with its clusters of sky-blue flowers on bare branches, beautifies our forests in May and June;

the *Lythraceæ* with the beautiful tree **'Pride of India'** (*Lagerstrœmia reginæ*—*Can.* Maruvāčala; *Mal.* Nīru̥veṇḍēku; *Tam.* Kodalemukki),—and the common shrub *Lawsonia alba* (*Can.* Madarañgi; *Mal.* Mailāñči; *Tam.* Marudōnri);

the *Combretaceæ* with the well-known **Rangoon Creeper** (*Quisqualis indica*), and several useful timber-trees of the genus *Terminalia*.

11. The Mangrove Family.

(Rhizophoreæ.)

Trees or shrubs, mostly in brackish water. Leaves opposite, with stipules. Flowers radial. Ovary inferior.

The coasts of India and other tropical countries are lined with peculiar flora called '**the Mangrove**' to which belong several trees of the *Rhizophoreæ*, e.g., *Rhizophora mucronata* (*Can.* Kāndel) and *Bruguiera parviflora*, as well as some shrubs of other families, *viz.*, *Avicennia officinalis* (*Can.* Uprunja) the spinous *Acanthus ilicifolius* (*Can.* Hoḷečuḷḷi), and the fern *Acrostichum aureum*.

The peculiar habitat of these plants has conditioned their peculiar structure.

1. **Xerophilous and hygrophilous habits of plants.**—Even a child knows that one of the conditions for the healthy growth of a plant is a regular supply of water. There is a constant flow of water in a tree from its root up to the leaves. But this flow must not be too weak, or else the leaves begin to fade and the plant dies. The flow must also not be too strong, or else the plant is overfed, becomes sickly and finally dies.

Now, the supply of water is not the same in every place. Plants growing near a river-side always have water enough to drink; plants growing on dry ground, however, have very little water to feed on. The supply of water is also not the same at all times of the year. There is plenty of water for every plant during the rainy season, but hardly any during the hot season. Again, plants with long and deep roots, such as large trees, can draw water even during the rainless season from springs hidden in the depth, whereas many small plants with short roots cannot reach any such reservoir.

Plants that have a rich supply of water at their disposal, therefore, generally possess certain arrangements in the structure of their leaves and stems to facilitate the transpiration of water at their surface, that is to say, their structure is *hygrophilous** (see "Helps to promote transpiration" in II. Part). But such plants as have only a scanty supply of water must be very frugal with it, they must reduce the process of transpiration to a minimum, and their structure is said to be *xerophilous* § (see "Means to check too much transpiration" in II. Part). Plants that are able to adapt themselves to various conditions as regards the supply of water in the different seasons are said to be *tropophilous* † (see Teak tree).

2. **Xyrophilous structure of the Mangrove.**—If we examine the leaves of a Mangrove tree, *e. g., Rhizophora mucronata,* under a microscope, we find that they are covered with a thick coat,

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* From Greek *hygros*, wet, and *philos* loving. § From Greek *xeros*, dry, and *philos*, loving. † From Greek *tropos*, a turn.

called the cuticle, preventing the evaporation of water accumulated in the cells of the epidermis. We further find that there are a number of additional layers of cells filled with water below the epidermis of the upper side of the leaf which may be said to be a reservoir of water. The stomata are deeply set in the epidermis. Many of the interior cells contain a slimy substance. The leaves of the tree have a decidedly xerophilous structure like so many plants growing in dry places.

At first sight, this fact must cause some surprise to the observer: for the Mangrove lives on moist soil, and we should, therefore, expect a hygrophilous rather than a xerophilous structure. However, if we think about it a little more, we understand that the Mangrove must necessarily be thus equipped. The soil in which the tree grows is moist but salt. If the tree were to absorb a large quantity of salt, the vessels in root and stem would be clogged by salt, which would cause the death of the tree. The tree must, therefore, reduce the quantity of water taken by the roots to a minimum, which is effected by diminishing the action of transpiration. The water absorbed is thus not freely transpired but retained by the leaves, and the percentage of salt is kept at a low rate.

The diminution of the flow of the sap is required for a second reason. Breezes are constantly blowing on the sea-coast. (The heat of the sun's rays warms the land much more than the sea, the hot air on the land rises, and in flows the cool air from the sea. That is the daily sea-breeze by day. The reverse takes place at night. The land cools down much sooner than the sea, the warm air over the sea rises and is replaced by a stream of air from the land, which we call land-breeze.) A plant like the Mangrove tree that is thus constantly exposed to winds is likely to wither easily and, hence, must be protected against too great a loss of water by transpiration.

3. **Rooting in the muddy soil.**—The soil in which the Mangrove grows is loose and muddy, and the tides continually shake the plant. The plant has to meet these unfavourable circumstances and is for this purpose admirably provided. It sends out from its trunk numerous horizontal adventitious roots which

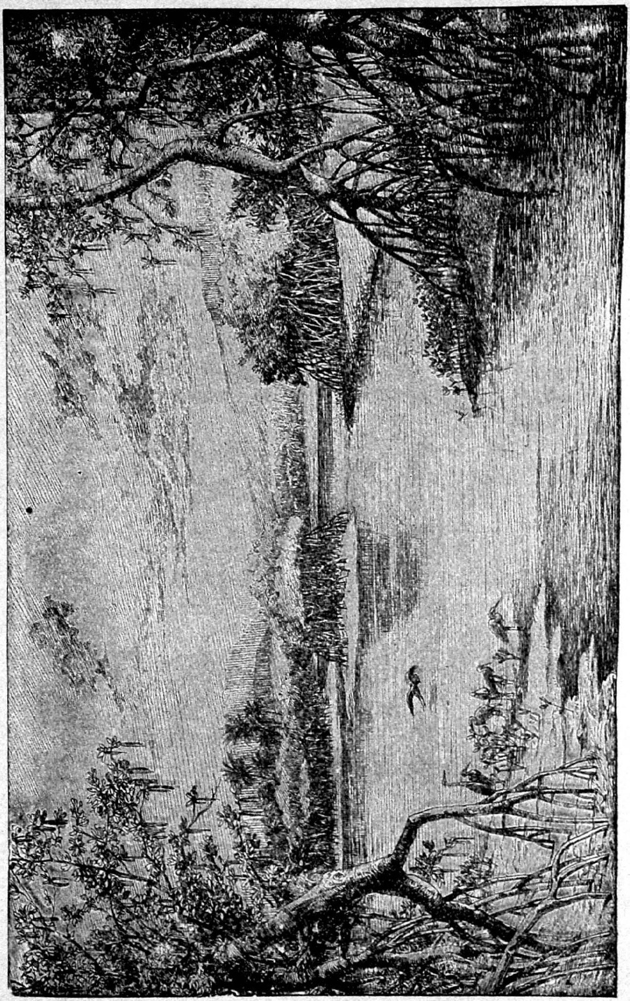

Fig. 41.—Mangrove growing on the banks of brackish waters.

by means of vertical shoots manage to get a firm hold in the soft mud. Such adventitious roots spring even from the branches. Mangrove swamps thus obtain a peculiar appearance, especially at low-tide, when the whole grove seems to be lifted over the water, as if standing on stilts, or looks like so many spiders standing on their long legs. The water

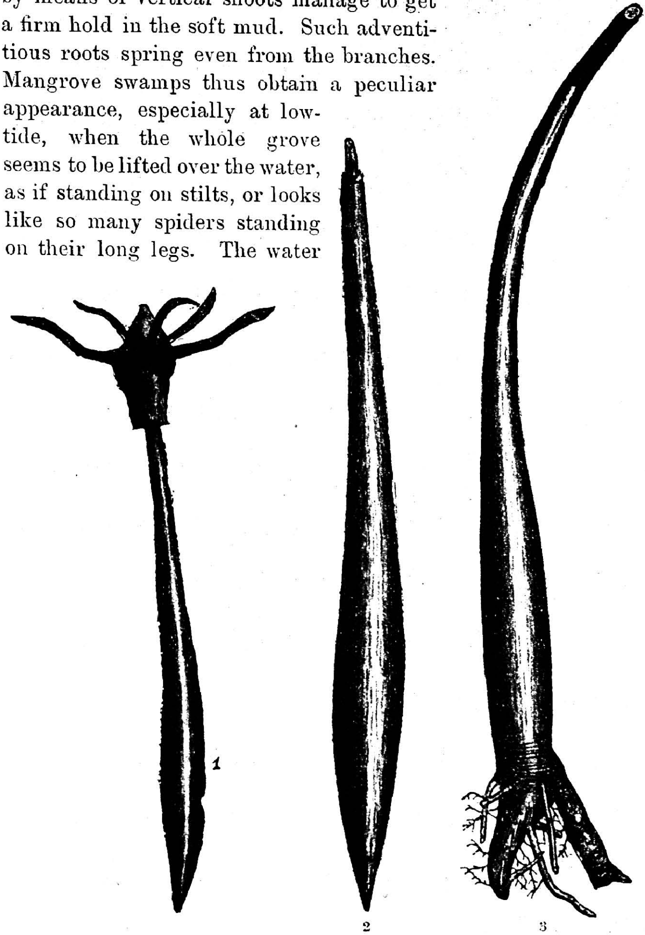

Fig. 42.—*Bruguiera gymnorrhiza* (Kandelia Rheedii), embryos in $^3/_4$ natural size: 1. still sticking in the fruit; 2. detached, with the plumula at the top; 3. rooted, only the basis of a shoot.

can now flow to and fro under the trunks just as under the piles of a pier, the stems remaining firm.

4. **Germination of the seed.**—But what happens with the seed? Is it possible for the germinating seed to take root in such an unsteady soil as the beach affords? Provision is made also for this difficulty. Seeds, as a rule, take a long rest before they germinate. The seed of the Mangrove tree, however, is an exception to the rule; it begins to germinate while still on the tree. The radicle of the embryo pierces through the apex of the fruit, and forms a long spear-like body (fig. 42, 1). The little warty projections seen on it indicate the future side-roots. After several months the seed, or rather the young plant, parts from the parent tree, drops into the soft mud like a falling arrow and remains there upright, the side-roots growing quickly and fixing the tender plant in the unsettled soil. Thus the tender shoot which unfolds its leaves soon after, is kept above the water.

5. **Breathing of the roots.**—Every growing part of a plant requires the oxygen of the air to sustain its life. So also the root of the Mangrove tree. But the muddy soil is destitute of oxygen which is used up in the process of decomposing the vegetable substances lying there. Other plants that have to live under similar conditions such as the Lotus (page 3) supply their roots with air by channels extending from the leaf blades to the extremest points of the root. But such a system of channels in the stem would

Fig. 43.—Breathing roots of Mangrove.

not do in the case of a tree like the Mangrove, as it would lessen the mechanical strength of such a tall tree with its branches. How, then, can the roots of the Mangrove tree breathe? They simply throw up little branches above the water level (fig. 43) containing large spaces in them and holes at their ends, by which they can get sufficient air to breathe.

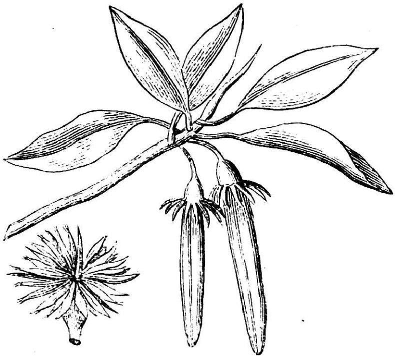

Fig. 44.—Branch of a Mangrove tree (*Bruguiera*) with fruits. On the left side the flower of it.

6. **Flowers.**—The flowers of the Rhizophoreæ are radial like those of the myrtles, the calyx and the corolla being variously lobed, and the stamens numbering usually double the number of the petals (fig. 44).

12. The Cactus Family.

(Cactaceæ.)

Leafless, succulent herbs. Flowers usually radial with indefinite petals and stamens. Ovary inferior. Fruit a berry.

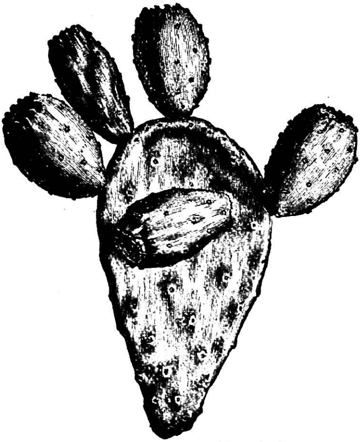

Fig. 45.—Opuntia with 5 fruits.

This is an American family, but some cactuses, principally the **Prickly Pear** (*Opuntia Dillenii*—*Can.* Jidegalli, Mullugalli; *Mal., Tam.* Nāgatāli; *Tel.* Nāgajamudu) and the **Night-flowering Cactus** (*Cereus*

grandiflorus, Can. Kaḷḷi) are very widely naturalized in India. They are *desert plants* and are, accordingly, by the peculiar structure of their leaves and stems enabled to endure the longest drought. Leaves with their large surfaces, which allow a great

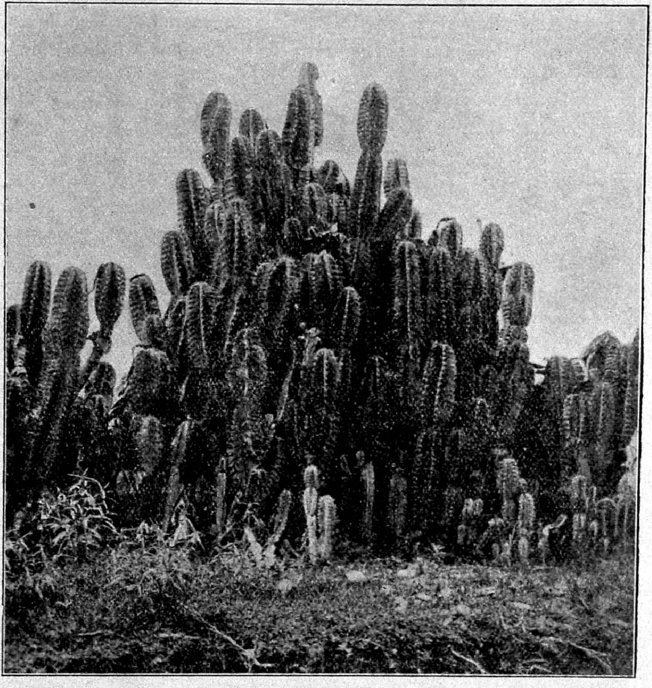

Fig. 46.—The Night-flowering Cactus (*Cereus grandiflorus*).

deal of the water to evaporate, are dispensed with and become dry prickles. But the Cactus cannot do without starch to grow on, and so the thick stem always remains green and does the work of the leaves in the preparation of starch from the air. The moisture of which the plant gets a very scanty supply is stored up, as in a reservoir, in the fleshy parts of the stem and

evaporated very frugally, the epidermis of it being thick and almost water-tight, the stomata in it being very few, and the sap becoming a thick and slimy fluid which does not easily pass into vapour. Thus the plants are able to thrive even when everything around them is dried up. Being the only succulent things in the deserts in which they grow wild they have to protect themselves, and this is done by turning the leaves into prickles which are very sharp and cause severe wounds.

There are 3 distinct forms of them, namely the globular (fig. 47, the central plant), the columnar (fig. 47, to the right), and the lobed or jointed (fig. 45). The Prickly Pear (*Opuntia Dillenii*) and the night-flowering *Cereus* have very showy flowers. Their fruits are soft and edible. In Mexico the Prickly Pear is cultivated for the sake of the cochineal insect that lives on it and yields a red dye. Here in India it is used for fences. Lately a variety of Opuntia without prickles was reared, which will, perhaps, enable us to make deserts more habitable, if the plant can now be used as fodder for cattle.

Fig. 47.—A group of Cactaceæ.

One plant, often called 'Cactus' is really a Euphorbia: it has to live under similar conditions and has developed the habits and appearance of the Cactus (see Euphorbiaceæ).

Bryophillum calycinum (*Can.* Kāḍubasale) belongs to an allied family (*crassulaceæ*), and is also xerophilous in its habits and structure. Buds are formed in the edges of the leaves, from which young plants are produced.

Fig. 48.—*Bryophillum calycinum.*

13. The Cucumber and Gourd Family.

(Cucurbitaceæ.)

Climbing herbs, with large, rough, alternate leaves and lateral tendrils. Flowers radial, unisexual. Petals more or less united. Ovary inferior, 3 carpels.

The Cucumber* (*Cucumis sativus*).

(*Can.* Mullusaute. *Mal. Tam.* Mulluvellarika. *San.* Urvāruka, Karkati.)

1. **Fruit and its Use.**— The Cucumber is extensively cultivated for its fruit. A cross-section through the fruit, a berry, shows the fleshy pulp outside and numerous seeds embedded in 3 divisions in a sticky, jelly-like mass inside.

2. **Germination.**— The seeds that fall on moist ground soon begin to germinate, the sticky flesh round them drying up and fixing the seed firmly to the ground. When germinating, the main root first appears out of the pointed end of the seed (fig. 49. 1)

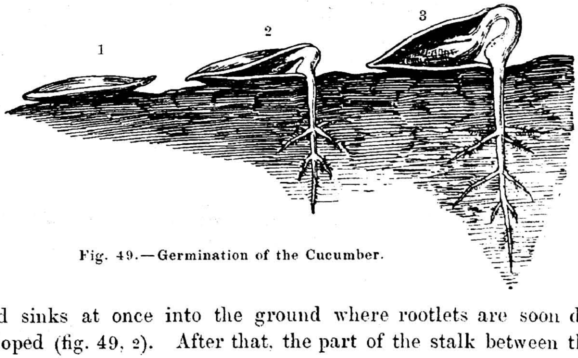

Fig. 49.—Germination of the Cucumber.

and sinks at once into the ground where rootlets are soon developed (fig. 49, 2). After that, the part of the stalk between the root and the seed-bud begins to grow, but as the root is moored in the ground and the seed-shells stick firmly to the earth, the stalk becomes a small bow, bent upwards (fig. 49, 3) until by its

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* If *Cucumis sativus* is not at hand, any other of the many cultivated kinds of Gourds, Melons, or the Pumpkin, will do equally well as another type of the family.

continued growth it draws the seed-leaves out of the seed-shells. If some seeds are similarly laid on the ground, but freed from the sticky mass round them, they also germinate after a short time, but as the seed-shells are not gummed to the earth, the stalk lifts them up, and as the seed-leaves can get rid of their covers only with great difficulty, the plants may perish. This shows *why the seeds,* when ripe, *must have* such a *sticky, jelly-like mass round them.*

The fruit does not open by itself to let the seeds escape. For this purpose the help of man is required in the cultivated kinds, and that of animals in wild ones. Like numerous other plants whose seeds are dispersed by animals, the Cucumber has, therefore, a *fleshy, edible pulp which attracts animals.* When perhaps a boar eats such a fruit, many seeds, to be sure, will be devoured together with the pulp. The number of seeds, however, being very great, this is not a great loss. On the other hand, some seeds will stick to its mouth and legs, and will thus be spread far and wide.

The seedlings show a peculiarity, which we have already noticed in the leaves of the Bean (see page 35). They *fold up their seed-leaves* face to face *at sunset,* and expand them when daylight comes again. We have learned the importance of these movements, but here the folded seed-leaves seem to afford protection to the young shoot between them, which being very tender might be liable to damage owing to the reduction of temperature during the night.

3. The **Stalk,** as well as the leaves, are covered with numerous *bristly hairs* as a protection against animals. The hollow, five-edged *stem is succulent and long,* and hence not able to stand upright. It, therefore, lies straggling on the ground or climbs with the help of its *tendrils.* These are wiry appendages of the leaves, rising from the base of the leaf-stalk. The ends of these tendrils move slowly, but continuously round, like the hands of a watch. The time they require for one circuit differs and depends chiefly on the temperature. If we put a little stick in the way of the moving tendril, we can notice the following. A few hours after the tip of the tendril touches the stick, it will have formed a

sling round it. Some time later we shall find the stick wound round several times, and in the course of a few days the part of the tendril between its base and the stick will be coiled up like a cork-screw. The *coiling* is always accompanied by *twisting*, and since the base and the end of the tendril are fixed before these processes take place, the directions in which the tendril coils round must necessarily be different at the two ends. Every coil has, therefore, a turning point in the middle (fig. 50, x). If a tendril cannot find a support to coil round, it produces little disks from its epidermis and fastens to any flat object, or it penetrates into any crevices. In this way, the creeper fastens itself to various objects within its reach, and as the corkscrew-like tendrils act like springs, the wind or any shaking influence cannot easily tear away the plant from its support. That part of the tendril which holds the support soon hardens, thus preventing the tendril from slipping and losing its support again.

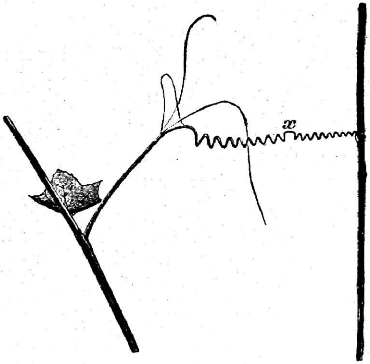


Fig. 50—A twig of *Luffa acutangula* with tendril.

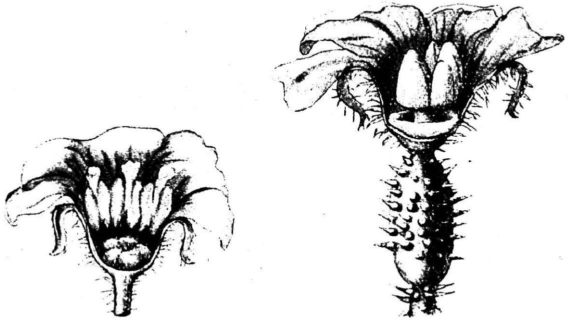
4. The **Leaves** are spirally arranged round the stem. But as a plant that lies or creeps on the ground can receive light only on *one* side of its stem, all its leaves should be directed to that side. To this end the long leaf-stalks make all sorts of turns and twists, thereby placing the leaves so that not one of them shades the other.

The leaves are *broad* and *cordate* (heart-shaped), the largest measuring about 5 inches each way. If we remember how succulent all the parts of the plant are and how much water it therefore requires, we can easily see the advantage the plant derives

from the largeness of its leaves. Large leaves cover more ground than small ones; hence they prevent evaporation of water from the soil in a greater measure than could be done by smaller leaves.

Large leaves are liable to be torn by the wind much more easily than small ones; and in heart-shaped leaves like those of the Cucumber the weakest part is the base. Therefore this particular part is specially strengthened: there are 5 or 7 strong ribs issuing from the base of the leaf like fingers from the palm of the hand, and two of them form the margin of the leaves for a small stretch like the hem of a garment.

5. The **Flowers** rise singly or in small clusters from the axils of the leaves. The calyx and the yellow corolla are combined at their base. The corolla forms a five-lobed bell. So far all flowers of the plant are alike. But if we proceed to examine their stamens and pistils, we find that most of the flowers have



1 2

Fig. 51.—*Cucumis sativus*, 1. Staminate. 2. Pistillate flower (the front part of the corolla is removed to show the central organs).

only stamens (fig. 51, 1), whilst some have only pistils (fig. 51, 2). The former are known as staminate or male flowers, the latter as pistillate or female flowers. The flowers, then, are *unisexual*. But as both kinds of flowers are on the same plants, they are called *monœcious** plants. Insects carry the pollen from one

* From Greek *monos*, one, and *oikos*, a house.

flower to the pistil of the other. To attract them there is nectar at the base of the corolla, to reach which they must penetrate far into the flower, which is lined with thick hairs under which the nectar lies. In the act of busily seeking after the sweet liquid, the insects cannot help touching the male or the female organs, as the case may be, and so fertilize the ovules.

Other Cucumbers and Gourds and allied Families.

The Gourds grow well in the warmer parts of the earth, especially within the tropics. Many of them are cultivated for their eatable fruits and are very much alike in their general habits. They can be best distinguished by their various fruits. The commonest are the **Squash Gourd** or **Common Gourd** (*Cucurbita maxima* — *Can.* Kumbaḷa; *Mal.* Čakkarakumpaḷana; *Tam.* Kumbaḷam); the **Pumpkin** (*Cucurbita pepo* — *Can.* Būdi-kumbaḷa; *Mal.* Kumbaḷam; *Tam.* Kalyānapūčuni); the **Water Melon** (*Citrullus vulgaris* — *Can.* Baččangāyi; *Mal.* Vattakka; *Tam.* Vattākku); the **Bottle Gourd** (*Lagenaria vulgaris* — *Can.* Kahi sōre; *Mal.* Kaippačuram; *Tam.* Sūrai); the **Luffa** (*Luffa acutangula* — *Can.* Hīre; *Mal.* Piččakam; *Tam.* Pīrku); the **Snake Gourd** (*Trichosanthes anguina* — *Can.* Paṭla; *Mal.* Paṭōlam; *Tam.* Puḍōl); the **Momordica** (*Momordica charantia* — *Can.* Hāgala; *Mal.* Pāval; *Tam.* Pāgal); the **Cephalandra** (*Cephalandra indica* — (*Can.* Toṇḍe; *Mal.* Toṇḍi; *Tam.* Kōvai); the **Common Melon** (*Cucumis melo* — *Can.* Kekkarike baḷḷi, Ibbuḍlu).

Allied to the Cucumber Family is the **Passion Flower Family** (*Passifloreæ*), likewise climbers with tendrils. Some of them, *e.g.*, Passiflora fœtida, grow wild, others, *e.g.*, Passiflora palmata, are cultivated in gardens for the sake of their peculiar flowers which have a very pretty corona of filiform appendages arising from the tube of the calyx. "The name 'Passion flower' was due to resemblances, which the mystical Fathers of the Church discovered more readily than we can. The five anthers represented the five wounds of our Saviour, the triple style the nails, the stalk of the ovary the main pillar of the cross, and the thread-like corona, the glory round His head".

The **Papaw Tree** (*Carica papaya*), a native of America, is another plant belonging to this family. The flowers are, like those of the Gourds, unisexual. The two kinds of flowers, however, do not grow on the same plant, but on different plants. They are therefore called *diœcious*.* The milky sap of the tree has the peculiar property of making raw meat tender by partly digesting it.

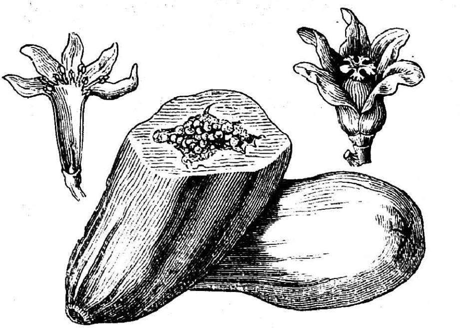


Fig. 52.—Staminate and Pistillate flower of the Papaw tree. Below 2 fruits, one opened by a cross-cut showing the seeds.

SUB-CLASS 2.—GAMOPETALÆ.

Plants with 2 floral envelopes: calyx and corolla. Corolla with united petals, the stamens generally inserted on it.

14. The Coffee Family.

(Rubiaceæ.)

Trees, shrubs, or herbs with opposite simple leaves and stipules. Flowers radial. Corolla tubular, 4 or 5 lobed; stamens as many inserted on the corolla. Ovary inferior, of 2 carpels.

The Coffee Tree (*Coffea arabica*).

(Plate No. 633.)

(*Can.* Kāphi. *Mal.* Bunnu. *Tam.*, *Tel.* Kāpi.)

1. Coffee is the seed of a small tree, cultivated in India, but a native of Arabia. Under cultivation the shrub is generally

* From Greek *di*, two, and *oikos*, a house.

not allowed to grow more than 6 or 8 feet high (why?), but if left to itself would become a small tree.

The **Leaves** are oblong and pointed, the margins being slightly waved. They are placed opposite one another, and in such a way that every pair stands crosswise over the next lower pair (*decussate*). So also the many branches. This ensures the advantage of the stem being equally loaded. Their surface is smooth and shining, a property which prevents too rapid an evaporation of the sap in the leaves (*cf.* Mango tree, page 23).

Fig. 53.—The Coffee tree.

2. The pretty white and rose-tinted **Flowers** stand in little clusters in the axils of the opposite leaves and have a most delicious fragrance. They are tubular with 4 or 5 narrow lobes

(fig. 53) which are twisted in the bud. These lobes thus protect, within them, the short-stalked stamens, which number as many as the lobes of the corolla, and are inserted at the mouth of the floral tube just between the lobes. There is one style (Plate No. 633, 4) with a 2-cleft stigma.

3. When the flowers fade, the **Berries** come in their place. They are first green and become blood-red when ripe (5), bearing the segments of the calyx on the top. The fleshy pulp encloses 2 horny seeds lying face to face (6 and 7) within a kind of skin called the "parchment". They are flat on one side with a deep ridge, and on the other side curved (8 and 9). These are the so-called Coffee-beans. A transverse section of the seed (10) shows how the seed-leaves are folded in it.

4. **Cultivation.**—The Coffee plant requires a well drained rich soil, such as is found in hilly forests. It grows best in a humid climate, and frost is fatal to it. In hot and dry places Coffee is successfully grown in shade. The plants are reared from seed in a nursery and, when a year or two old, planted in their permanent places in the plantation generally under partial shade. As shade-trees, such are preferred as go to enrich the soil, *e.g.*, *Bauhinia*, *Poinciana, Sesbania,* and other *Leguminosæ.* Coffee being an exhausting crop manuring is required.

5. **Enemies.**—The bug and the borer are dreaded enemies of Coffee plantations. The latter (*Clytus coffeophagus* or *Xylotrechus quadrupes*) is a little beetle whose larva lives under the bark and in the wood of the tree eating its way through the wood up and down the tree, and penetrating to the very end of the taproot. Its presence in the Coffee tree becomes apparent by the sickly look of the tree, the older leaves becoming pale and the berries falling off unripe with the leaves. The best remedy suggested is the immediate removal and destruction of the affected tree and the scraping, rubbing, and washing with acids of healthy ones to destroy the eggs deposited in the natural fissures of the bark.

6. **Preparation of Coffee.**—When ripe the fruit is gathered or shaken on cloths spread under the trees. The berries are then passed between rollers, which are close enough together to

crush the fleshy part, but not close enough to crush the seeds. After being crushed the pulp is washed away, and the berries, still in their skin, are set to dry in the sun. When dry they are again passed between rollers set closer together which now break the skin. The broken skin is blown away, and the beans are sorted and packed.

The raw beans are greenish in colour, and do not smell or taste like coffee. When coffee is wanted, the beans must be roasted, *i. e.,* placed in an iron vessel, which is turned over a fire. The roasted beans are then ground to powder, on which boiling water is poured, and then we get coffee.

This drink has a stimulating effect on the system, or, in other words, it rouses the nervous system to fresh activity, the sense of hunger is suppressed and the desire to sleep is driven away. This is due to a substance, called "Caffeine", contained in the Coffee beans. If this substance is taken in larger quantities, it acts as a poison; very strong coffee, therefore, produces palpitation of the heart, congestion of blood in the brain, trembling of the muscles and similar affections of the nerves. Coffee is not a food in any way, but is merely a stimulant like alcohol.

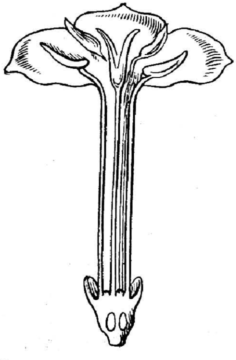


Fig. 54.—Flower of Ixora. The front part of the floral tube with the fourth lobe is removed and the ovary is cut open.

Other Plants of the Coffee Family.

The **Scarlet Ixora** (*Ixora coccinea* — *Can.* Kēpala, Kisgāra; *Mal.* Četti; *Tam.* Veḍḍi; *San.* Pātalī) is a very common shrub growing wild on all our hills, and is a general favourite because of its beautiful, scarlet flowers and edible, crimson berries. The stem is woody and bears opposite, sessile leaves, which being tough and leathery keep green and enable the plant to flower even in the hottest and driest season of the year. The flowers are in dense clusters at the ends of the twigs. They consist of

a long slender tube which spreads into a four-parted limb. The 4 yellow stamens are, just like those of the Coffee flower, short-stalked and inserted at the base of the limb between the lobes (fig. 54).

The **Cinchona Tree** (*Cinchona succirubra*) is a native of Peru, but is now cultivated in India also. Its bark contains a very bitter substance, called Quinine, which is a most valuable antidote against malarial fever. — *Mussœnda frondosa* (*Can.* Bellotṭi; *Mal.* Veḷḷilla) is an ornamental shrub in our hedges. One of the sepals (segments of the calyx) develops into a large, white leaf which shows the insects, on which the plant depends for fertilization, where the flowers are (compare Mango, page 25).— In gardens we often see the beautiful **Gardenia** with its white sweet-smelling flowers, which sometimes "double" (compare Rose, page 43).— In *Morinda citrifolia* (*Can.* Maradarasina, Poppili; *Mal.* Nōṇāmaram; *Tam.* Nuṇāmaram; *Tel.* Mulugu; *San.* Dāruharidrā) the single flowers stand on a common receptacle. The fruits all grow together in one mass as they ripen, and look as if they resulted from a single flower (compare fruit of Ananas). A red dye is prepared from the root of this plant.

5. The Composite Family.

(Compositæ.)

Usually herbs. Many single florets are gathered into a dense head with a broad receptacle, which is often furnished with chaffy scales and surrounded by whorls of bracts so that the whole might be mistaken for a single, large flower. Florets: calyx reduced to scales or bristles; corolla either *tubular* or *ligulate* (strap-shaped); stamens 5 with free filaments but cohering anthers, which latter enclose the style. Ovary inferior. Fruit a dry, one-seeded case, called *achenium*, often crowned by a tuft of hairs, called *pappus*.

The Sunflower (*Helianthus annuus*).

(*Can.* Hottutirugana. *Tam.*, *Tel.* Sūryakānti).

This is an annual herb from S. America which is now cultivated in gardens all over India. In some countries chiefly in

Southern Russia and in the Balkan states, it is also grown for its seeds, from which a valuable oil is made.

1. The young plants soon develop into strong and big herbs which sometimes attain a height of three yards. The thick **Stem** is branched only in its upper part. It forms a tube which is filled with loose pith.

2. The **Leaves** are large and cordate. If a thread be tied to the leaf-stalk of one of the lower leaves and then taken to the second, third, and so on, above it, one can clearly see that the leaves are *spirally arranged* around the stem (fig. 55) so that, if a small plant is looked at from above, the leaves appear in the form of a rosette. By this arrangement each leaf gets the largest possible share of the sunlight.

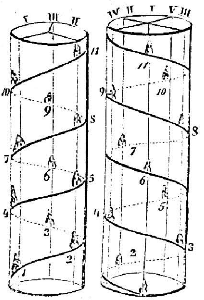


Fig. 55.—Spiral arrangement of the leaves round stems.

The leaves *bend down to the ground* with their pointed ends, so that the *rain water* falling on them is *conducted outside.* With this arrangement the structure of the roots stands in beautiful harmony. The Sunflower plant being a tall herb, one would expect the roots to be long and strong so as to fix the plant firmly in the ground. But this is not the case. The side-roots are very short, and do not stretch beyond the ends of the leaves. As a compensation for this they are, however, very numerous and divided into so many little branches that, if the plant is taken out of the soil, the earth sticks together forming, with the roots, a compact mass which can be shaken off only with much difficulty. The water that is drained off from the centre to the circumference of the plant, falls on the ends of the roots just in the same way as we have seen in the Mango tree (page 25), with one difference, namely, that, the leaves of the Sunflower plant not being close together, the rain also pours down within their circumference; consequently we find that the tiny sucking roots are not only arranged in a ring corresponding to the outer circle of the leaf-ends, but that they are also distributed all over within that circle.

3. The stem and branches bear each on their tips one great **Flower,** which turns its face towards the sun (hence the name!). If we cut vertically through such a "flower" (fig. 56), we can see that there are really many small flowers placed on one receptacle (R.). The whole is, therefore, not one flower, but an aggregate of

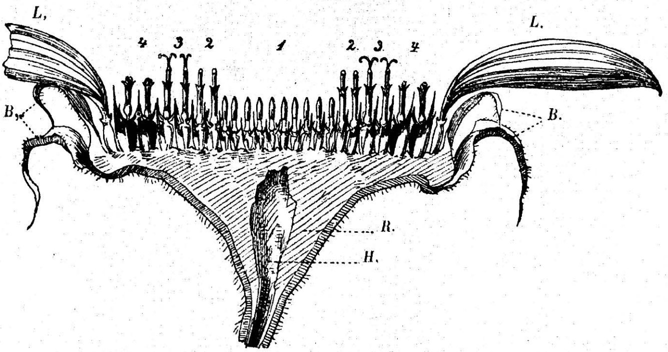


Fig. 56.—Longitudinal section of the head of the Sunflower. 1—4 Tubular florets; 1. not yet opened; 2. the pollen is pushed out of the flower tube; 3. the style protrudes and exposes its two-cleft stigma; 4. faded flowers.—*L.* Ligulate florets. *B.* Bracts. *R.* Common receptacle. *H.* Hollow part of receptacle and stem.

flowers or a *head of flowers.* Hence the order to which the Sunflower belongs is called "composite". This bunch or head of flowers is surrounded by several series of scaly leaves, called bracts (*B.*), which protect the florets under them when in bud. The florets are of two different kinds: those in the middle have a small yellowish, tubular corolla (*tubular florets* 1, 2, 3, 4), whereas those on the margin possess a corolla stretched out in a long, yellow tongue (*ligulate florets,* L).

(*a*) *Tubular florets.*—The head of a Sunflower generally shows florets in various stages: those in the centre may be mere buds (1); then follow one or two circles of opened florets bearing clusters of pollen at their tops (2); then come florets with their forked styles visible (3); and finally florets which are faded, form the outer circles (4). Let us now examine one of the tubular

florets (fig. 57). The ovary(*O.*), we find, rests in a hole of the chaffy receptacle. It bears two small scaly leaves on it which represent the calyx-leaves (*C.*). In some species of this order, as for instance the Sow-thistle (*Sonchus oleraceus*) or Lettuce (*Lactuca*), these calyx-leaves crown the fruit, when ripe, with a feathery ring of hairs, called pappus, by which the wind carries the seed far away. The seeds of the Sunflower have no such pappus.

The corolla of the inner florets is, as already remarked, a narrow tube. At its base there is a ball-like enlargement, and the upper part of it ends in 5 small and pointed teeth. There are 5 stamens within the corolla tube whose filaments are separated, but whose pollen-bags or anthers are joined into a tube (fig. 57, *A.*). The anthers open on their inner side and set the pollen free. The style (*Sty.*), while seeking its way through the very narrow tube of the anthers, cannot help pushing up the pollen out of the tube where the pollen accumulates in small clusters (fig. 57, 1). Insects that visit the flower are sure to remove it quickly with their bodies and legs. And then only the style opens its two-forked stigma in order to receive pollen from

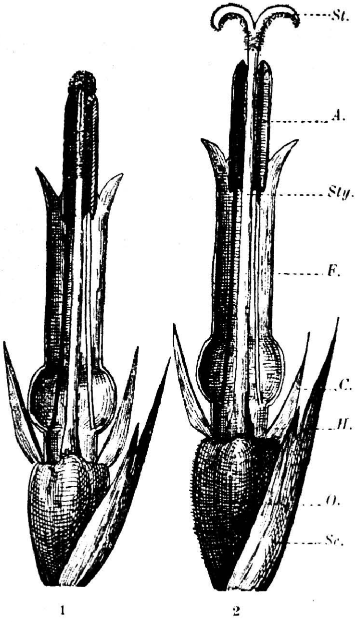


Fig. 57.—Tubular florets of Sunflower (5 times enlarged). The flower-tube is opened. *Sc.* Chaffy scale of the receptacle. *O.* Ovary. *C.* Calyx. *F.* Filament. *Sty.* Style. *A.* Tube of joined anthers (opened). *St.* Stigma. *H.* Spot where honey is secreted.

another flower (fig. 57, 2). It is a well established fact that fertilization is generally achieved not by the pollen of the same flower, but by that of another. Self-fertilization generally produces seeds of an inferior and degenerated sort. We see in this case, as well as in many other plants, a wonderful contrivance for *cross-fertilization.*

(*b*) *Ligulate florets.*—If insects have to render the flower this very important service, they must also be attracted by some means. The flower contains honey in great quantities which is secreted at the base of the style and often fills the whole globular part of the tubular florets (fig. 57, *H.*). But a single floret would be so inconspicuous that it would hardly be noticed by the guests which are so eagerly expected. We see, now, how advantageous it is for the plant that the small inconspicuous florets should be placed together in large numbers forming heads of flowers (compare Mango, page 25). The effect of their being clustered is enhanced by the ligulate (strap- or tongue-shaped) florets on the margin. We seek in vain for styles and stamens in these flowers: they are sterile. But by *attracting the useful insects* they fulfil the purpose for which they were created.

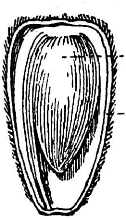


Fig. 58.—Fruit (*achenium*) of the Sunflower (opened). *S.* Seed. *C.* Seed-cover.

4. The **Fruit,** when ripe, does not open, but remains shut and is called an *achenium.* Each fruit contains one seed under its hard cover. In fig. 58 the front half of the fruit case is removed showing how the seed in the case is connected with the base of the fruit by a small cord (called funicle). When the wind shakes the tall plants one against the other, the seeds fall and from the effect of the blow are scattered around (*cf.* Poppy, page 7).

The seed contains a fatty oil which serves as food for the young plant growing out of it eventually.

The Indian Cudweed (*Gnaphalium indicum*).

This plant may be taken as a type of the flora of high mountains. It is a small weed, branched from the root, all covered with white cotton, an ally of the beautiful Alpine "Edelweiss".

1. To understand its structure it is necessary to remember the *conditions of the Alpine climate.* The ruling influence of high lands is the diminished atmospheric pressure which brings in its train a number of secondary climatic effects.

The diminished atmospheric pressure is always accompanied by a decrease of the temperature in the shade and an increase of the heat of the shining sun. It also gives rise to great changes of temperature at day and at night. On the Kudremukh, a mountain of the Western Ghats, 6215 feet high, the thermometer stands in the month of April often at more than 40° *C* in the sunshine and falls to 14° *C* before sunrise. Another effect of the rarified air is the intensity of the sunlight.

Owing to its low temperature the air cannot hold so much water-vapour as the hot air in the plains. The vapour rising with the hot air from the plains is condensed when it reaches higher altitudes, giving rise to increased rainfall on the mountains. On the other hand, the thinner atmosphere contains less vapour and is often exceedingly dry. The result is rapid changes in the humidity of the air.

The daily changes of the upward and downward currents of air cause a continual movement of the atmosphere.

The rarification of the air, the intense radiation, the occasional dryness of the air, and the constant wind, all tend to produce intense evaporation, which every tourist will experience: everything dries up rapidly, the sweat on the skin evaporates, the skin becomes dry and brittle, and the sense of thirst is intensified.

2. *The flora of high mountains is adapted to their special climatic conditions.* Trees and shrubs are dwarfed, having short, gnarled and bent trunks with distorted branches and scanty foliage, partly due to the increased movement of the air. Herbs are on the whole xerophilous, distinguished by short stems forming rosettes, large root-systems, small thick leaves, often rolled up sideways and downward covering the stomata beneath, and completely covered by dense, air-entangling hairs, and the withered remains of dead foliage thickly coating the stems. Many of the low herbs are found huddled together like a flock of sheep and forming cushions like mosses. All these are ways

by which these plants are protected from loss of water, and most of them can be studied in Gnaphalium.

The flowers of Gnaphalium are not brightly coloured as Alpine flowers usually are, but have scarcely any colour becoming brown and rough when withering. They grow on a pretty long and branched stalk forming spikes.

Other Composites.

The Composite Family is the largest family of flowering plants, comprising about 12000 known species from all parts of world. But the proportion of plants which can be used by man is comparatively small. Some are used in medicine; some are aromatic, abounding in volatile oil; a considerable number are used as salad or pot-herbs.

Fig. 59. Vernonia cinerea, the seeds scattered by the wind.

They are divided into 3 tribes:—

1. Heads with the florets all similar and tubular:

The **Ash-coloured Fleabane** (*Vernonia cinerea—Can.* Sahadēvi; *San.* Ardhaprasādana).

The **Purple Fleabane** (*Vernonia anthelmintica—Can.* Kāḍājirige).

The **Safflower** (*Carthamus tinctorius—Can.* Kusubi).

Elephantopus scaber (*Can.* Nelamuččaḷa), the leaves of which appear in rosettes close to the ground at the beginning of rains, "and raise hopes of something good. Nothing more appears till about September, when a tall and promising stem shoots up, and, after further waiting, develops as plain and uninteresting a flower as could be seen" (A. K. Nairne).

Ageratum (*Ageratum conyzoides—Can.* Nāyituḷasi, Hēlukasa, Mugutigiḍa), a weed frequently met with in gardens, smelling like the leaves of the Tuḷasi plant.

Sphæranthus indicus (*Can.* Karaṇḍe), a prostrate weed that covers rice-fields in the cold weather.

Fig. 60.—Ligulate floret of Lettuce.
a. Ovary. *b.* Pappus.
c. Lower (tubular) part of corolla.
d. Upper part of it.
e. Joined anthers. *f.* Style.
g. Free filaments.

2. Heads with the florets all similar and ligulate:

Lactuca sativa, **Lettuce** (*Can.* Hakkarike palya, fig. 60 and 61),

Sonchus oleraceus, **Sow-thistle** (*Can.* Nāyi hakkarike).

3. Heads with a ray of ligulate and a disk of tubular florets:

Chrysanthemum (*Chrysanthemum indicum* — *Can.* Sēvantige), a common pot-plant.

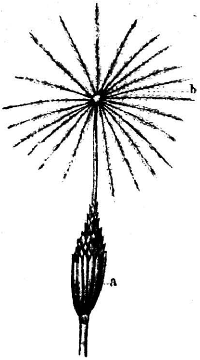


Fig. 61.
Fruit of Lettuce.
a. Achenium.
b. Pappus.

The **Sunflower** (*Helianthus annuus*),
Zinnia (*Zinnia elegans*),
Dahlia (*Dahlia variabilis*),
Cosmos (*Cosmos sulphureus*), all of them common garden plants, and

Eclipta alba (*Can.* Garga; *Mal.* Kaiyaṇṇi) a much-prized medicinal weed.

16. The Olive and Jasmine Family.

(Oleaceæ.)

Trees and shrubs with opposite leaves. Flowers radial. Stamens 2. Ovary superior, of 2 carpels.

Of this family various species of **Jasmine** (*Jasminum*—*Can.* Mallige) are grown in Indian gardens on account of the sweet scent and the beauty of their flowers.—They are all climbing shrubs with opposite leaves and radial flowers. The stamens and carpels are two each.

The smell of some of the Jasmine flowers is particularly strong in the evening. They also open their blossoms not in the morning, like many other flowers, but in the evening. This is surely not without good reason. If we look at the long and narrow tube, we may conclude that the honey at the bottom of the tube can be obtained only by insects with long tongues. Such are the moths that fly about at dusk. It is for this reason that the **Flowers** *are white,* that they *open in the evening* and *exhale such a strong and sweet scent* at that time, and that they *bend over* and are not erect like the buds (compare *Clerodendron!*).

The Double Jasmine (*Jasminum sambac—Can.* Duṇḍumallige) is, like the Double Rose, a product of horticulture (see Rose, page 42). One of the wild species is *Jasminum rigidum* (*Can.* Kāḍumaḷḷige).

The shrub *Nyctanthes arbor-tristis* (*Can.* Pārijātaka; *Mal.* Pārijātakam; *Tam.* Pavaḷamalligai; *Tel.* Krishṭi; *San.* Pārijāta) is also an example of this family. The limb of the corolla is white, but its tube is orange-coloured. The flowers open at night and fall off very freely in the early morning.

The **Olive Tree** (*Olea europæa*) is not found in India, but is extensively grown in the countries round the Mediterranean Sea for the sake of the excellent oil obtained from the pulp of its fruit.

An allied family is that of the *Loganiaceæ* to which the **Strychnine Tree** belongs (*Strychnos nux vomica; Can.* Kāsarka, Hemmushṭi; *Mal,* Kāññiram; *Tam.* Eṭṭe; *San.* Kāraskarah). The tree has shining, opposite leaves and greenish flowers. The fruits are like small oranges and contain many silky seeds resembling flat, round buttons. The seeds are very poisonous but yield a valuable medicine.

The plants of the Gentian Family (*Gentianaceæ*) are common on high lands and known for the gaiety of their flowers. Such a beautiful flower is that of *Exacum bicolor,* having four white petals tipped with blue and four large yellow anthers. Exceedingly pretty are also the white, fringed flowers of the aquatic herb *Limnanthemum indicum,* very cemmon in tanks throughout India. *Swertia chirata* (*Can.* Kiriyātu; *Tam.* Ciriyātu; *San.* Kirātanāmā) has bitter and tonic qualities like many other Gentians.

17. The Dogbane Family.

(Apocynaceæ.)

Mostly shrubs, generally abounding in milky juice. Leaves opposite or whorled. Flowers radial; petals 5, contorted in bud; stamens 5; carpels 2, usually free below. Fruit generally consisting of 2 narrow follicles.

The Rose Periwinkle (*Vinca rosea*).

(*Can.* Sadāmallige, Kempu Kâsigaṇagilu.)

1. This is a small shrub found everywhere in Indian gardens. It flowers throughout the year. Drought stops the growth of plants, and they generally drop their leaves. It does not seem to affect *Vinca rosea,* which remains green and flourishing when everything else is withering for want of water. What makes this little plant so hardy?

If you pull the plant up, you will notice that its **Roots** are long and extend beyond its branches. This enables it to get water from a greater space than most plants of its size can.

Fig. 62.—The Rose Periwinkle (*Vinca rosea*).

The **Stem** of Vinca does not grow high, but has numerous long branches, the tips of which only are erect. Small plants, like Vinca, generally have a herbaceous stem which does not last for more than one season. Vinca has a strong woody stem, in which it can store up foodstuff and moisture for the time of need. This stem, moreover, is covered with *a very tough and leathery bark* which will not easily allow the moisture

contained in its inner layers to evaporate. The sap in the stem is, besides, slimy, and slimy fluids, as a matter of fact, dry up very slowly (compare *Cactus*, page 54).

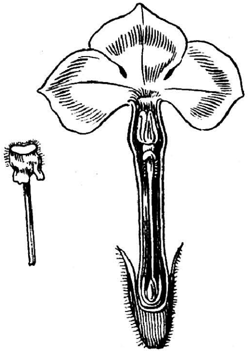


Fig. 63.—Flower of Vinca. The 2 front lobes and half of the floral tube are removed to show the stamens and the style. On the left side the upper part of the style with the hourglass-like stigma.

The elliptic **Leaves** of Vinca are placed opposite. They are shiny above and provided with a thick epidermis, which conditions reduce the evaporation (see Mango, pages 23 and 24). Touch the leaves and you will see that, though they shine and appear glabrous or smooth, there is a fine *coat of down* all round the epidermis. This also helps to reduce the evaporation.

2. The **Flowers** grow in pairs in the axils of the leaves. The calyx is divided into 5 filiform segments. The corolla consists of a long cylindrical tube spreading at its upper end into 5 broad limbs, which are contorted in bud, but are at right angles to the tube, when open. The mouth of the tube, tinged with dark crimson, is slightly raised, surrounded by a corona of hairs, and very narrow. But a little below, the tube widens making room for 5 sessile stamens which form a cone under which the hourglass-like stigma of the long and slender style is situated. The latter rises from the combined tip of 2 seed-vessels at the bottom of the floral tube (fig. 63).

3. **Pollination.**—Between the two seed-vessels there is a gland on each side which secrete nectar. Only insects with long tongues can get at the nectar at the bottom of such long flower-tubes. Such are certain night moths. They, in their turn, have to pollinate the flowers. The anthers are inclined over the flat top of the style and deposit their pollen there. But this part of the style is not receptive. The only part in which the style can receive pollen is the collar or seam of the hourglass-like stigma, which is sticky. Now, there are five

little openings between the five anthers through which the insect must stretch its tongue into the flower-tube. While doing so, the tongue brushes against the sticky sides of the stigma and deposits there any pollen that it might have brought from another flower. When the insect draws its tongue back out of the tube, it touches the pollen-masses lying loosely on the top of the stigma which readily adhere to the sticky tongue. Thus the pollen of one flower is carried to the style of another, and self-pollination is avoided.

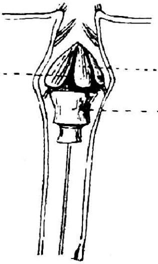


Fig. 64.—Longitudinal section of floral tube of Vinca. *A.* Anthers. *O.* Opening between anthers. *St.* Stigma.

Other Apocynaceæ.

The **Corrinda** (*Carissa spinarum*—*Can.* Garji, Korinḍa; *Mal.* Karanṭa; *Tam.* Kali; *Tel.* Kalivi) is a common thorny shrub, well fitted to thrive in dry regions, like Vinca, by the milky and slimy juice in all its parts, the tough bark of its woody stem. and the shining surface of its leaves. The flowers are very much like those of Vinca in the arrangement of the parts, the corolla-lobes, however, being narrower. The fruit is not a dry seed-vessel like that of Vinca, but a purple berry with some 4 seeds, embedded in an exceedingly sticky but nicely flavoured pulp. They are edible, and as a result, the seeds are carried by birds and animals to a distance from the mother plant, and the species is thus able to spread over the country. The fruits are also employed to make pickles and are considered superior even to the Mango for these purposes.

Alstonia scholaris (*Can.* Hāle; *Mal.* Ērilapāla; *Tam.* Ēḷilappālai; *Tel.* Ēdakūla; *San.* Jīvani) is valued for its bark which is used in medicine.

Tabernæmontana coronaria (*Can.* Nandibaṭlu; *Mal.* Tagaram; *Tam.* Nandyāvaṭṭam; *Tel.* Nandivardhanamu; *San.* Vishṇupriya) is a favourite garden plant for its pure, white, fragrant flowers.

Allamanda grandiflora (*Can.* Arasina-hū, Seitāna-hu, Kēḷa) with its large, grotesque, bell-shaped, yellow-flowers, and

the poisonous **Oleander** (*Nerium odorum*—*Can.* Kaṇagilu; *Mal.* Kaṇāvīram; *Tam.* Karavīram; *Tel.* Kastūripaṭṭe; *San.* Karavīrah) with its beautiful flower-bunches are likewise garden plants.

The **Pagoda Tree** (*Plumiera acutifolia*—*Can.* Kāḍusampige; *Mal.* Veḷuttaraḷi; *Tam.* Īḷattalari; *Tel.* Aḍaviganneru) looks "ugly when out of leaf, from the swollen truncated branches, but beautiful when adorned with large, lanceolate leaves and fragrant, white flowers with yellow throats" (A. K. Nairne).

Cerbera odollam (*Can.* Čaṇḍe; *Mal.* Utaḷam; *Tam.* Kāṭaraḷi) lives in salt swamps, adorning them with its thick foliage and its large bunches of white flowers. The fruit is, like the cocoanut, beautifully adapted for dispersion by running water. When a fruit drops into the water, the outer pulp decays, the fibrous covering serves as a swimming belt and the inner hard covering as a protective coat for the seed.

18. The Milkweed Family.

(Asclepiadaceæ.)

Shrubs often twining, usually containing a milky juice. Leaves opposite. Flowers radial; petals 5, contorted in bud, stamens 5. Anthers coherent, with the pollen masses resting upon the columnar stigma, forming a corona. Ovary of 2 carpels. Fruit 2 follicles. Seeds with a brush of hairs.

The Madar (*Calotropis gigantea*).

(*Can.* Ekka. *Mal.* Erikku. *Tam.* Arkkam. *Tel.* Arkamu. *Hind.* Madār. *San.* Arkāh.)

1. **Its Use.**—This plant generally grows wild. The *fibre* obtained from the stems of this plant is one of the strongest fibres known. The stems are cut into sticks about 18 inches long, dried in the sun for 2 or 3 days, battered afterwards, and then the outer bark is peeled off and the fibre picked out with teeth and fingers from

the inner bark, and then twisted into rope for cordage or fishing nets (Mukerji, *Agriculture*).

2. The **Stem** and the **Leaves** abound in *milky juice*, which protects the plant in many respects. It is acrid and poisonous and makes the plant distasteful to cattle. The viscid resin contained in it causes it to clot readily so that wounds through which it oozes out are soon shut up, thus preventing germs of decay from entering into the body of the plant. — The *down* on

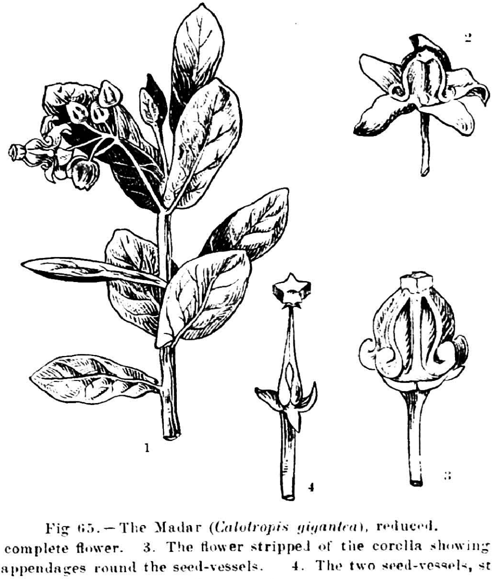


Fig 65.—The Madar (*Calotropis gigantea*), reduced.
2. A complete flower. 3. The flower stripped of the corolla showing the curved appendages round the seed-vessels. 4. The two seed-vessels, stripped of the appendages.

the stem and on the underside of the leaves affords the plant protection against the withering influence of dry winds. Owing to this and the thickness of the epidermis, the plant is, in spite of the size of its leaves, in a position to remain green even

during the hottest and driest part of the year. The leaves are pretty large, oblong, opposite and embrace the stem having very short petioles.

3. The **Flowers** grow in large umbels. The bluish, 5-lobed corolla is bell-shaped. Of peculiar interest is the structure of the essential or reproductive organs of this flower. What strikes us first when we examine it, are 5 large, wax-like, bluish bodies, curiously recurved, alternating with the corolla lobes and arranged round a central column (fig. 65, 3). If we remove them carefully, we shall find in the cavity 2 seed-vessels with a style each. These, however, are united at the top and support a 5-rayed stigma (fig. 65, 4). At each corner of this cake-like stigma a sticky gland is to be seen, to which 2 club-shaped pollen-masses are attached, each of them belonging to two distinct anthers. This is evidently a contrivance for cross-fertilization by the agency of insects (compare Orchids!). Insects that alight on the broad stigma of the style in search of nectar detach some of the pollen-masses with their feet, and carry them to another flower, which is thus fertilized.

4. The **Fruit** is made up of two large, ovoid capsules, called follicles, each splitting up in one line and containing numerous seeds packed together in beautiful order. Each seed is crowned with silky hair. When ripe the feather expands like an umbrella, which, caught by the wind, will be carried away to a great distance with the seed attached to it beneath. Compare this pappus with that found in some Composites (page 68). In this case the silk floss is formed inside the carpel, whereas in the Composites it is the persistent calyx on the top of the carpels which grows into long hairs and forms the means of transport.

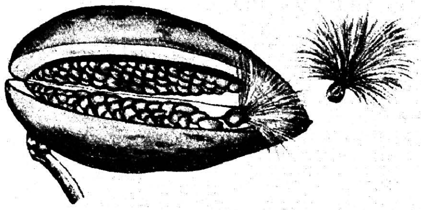


Fig. 66.—Follicle of *Calotropis gigantea*.

5. Most of the **other Asclepiadaceæ** are climbers. One of

them, *Hemidesmus indicus* (*Can.* Nāmadabēru; *Mal.* Nannāri; *Tam.* Nannāri; *San.* Bhadravalli), affords the so-called Indian Sarsaparilla. *Dæmia extensa* (*Can.* Juttuve, Pettatajank; *Tam.* Belaparti) is very common and possesses cordate leaves and greenish flowers.

19. The Bindweed Family.

(Convolvulaceæ.)

Herbs and shrubs with alternate, cordate leaves. Mostly twiners. Many with milky juice. Corolla funnel-shaped, folded and contorted in bud. Stamens 5. Ovary of 2 carpels, usually with 4 large seeds.

The Elephant Creeper (*Argyreia speciosa*).

(*Can.* Samudrapāla. *Mal.* Samudrajōgam.)

This is a huge climber, commonly found in thickets and jungles, especially near the sea. We choose this plant as a type of the lianas, a name given to climbing and winding plants in tropical forests.

1. **Why the Elephant Creeper climbs.**—Plants cannot live without light. If we grow any plant in a flower-pot and keep it in a room, it will invariably stretch its branches towards the window eagerly seeking the light. If it cannot get sufficient light, it will etiolate, *i. e.*, grow white from absence of the normal amount of chlorophyll in its leaves, and the stalks become unnaturally long, producing small and bent leaves but no flowers. The plant is sickly for want of the necessary light.—A dense forest produces the same effect. There is so much shade that hardly any herb can grow in it. How many plants die there for want of light! How many seeds fall there to the ground and germinate, but cannot grow further, perishing miserably in the dark thicket!

The seed of a liana has to germinate under such disadvantages and would certainly suffer the same miserable death, if it were not provided with certain qualities that other plants lack. Above all, the liana is distinguished by an unusually quick

growth, by which it brings its foliage to the top of trees in a very short time. The darkness and the damp air in the jungle are advantageous to its growth. It is as if the plant in its youth had no other aim than this, and as if everything else about its growth was subservient to this one end: it does not form many leaves; it does not produce branches; the stem does not grow in width; it only grows in length. The stem thus becomes so slender and weak that it cannot stand upright by itself. What may now be its fate? Shall it yet die in the struggle for existence?

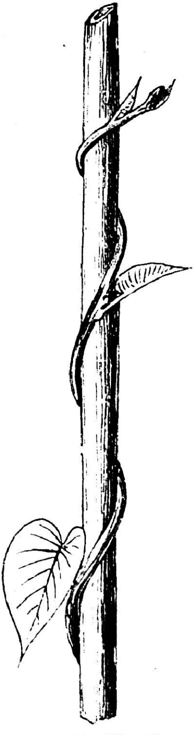


Fig. 67.—The "forerunning tip" of *Argyreia*.

It would certainly die, if it had not the wonderful ability to use as its support the very giant tree in its vicinity which threatened to be the cause of its death and to choke it. The Elephant Creeper climbs the tree winding round it. The leafless tip of the slender stem moves spirally until it finds something to grasp, round which it then winds from right to left, *i. e.*, in the direction opposite to that in which the hands of a clock move. If the stem cannot find any support, it sinks down to the ground, striking new roots at its nodes and rising again. If no vertical support can be obtained, the plant does not thrive well. Supports standing up vertically are preferred to any others, for they enable the plant to come to the light in the shortest time.

2. **The "forerunning tip" of the lianas.**—The tip of the creeper is of particular interest being characteristic of all climbers. There are only a few very small leaves or rather leaf-buds on it at large intervals, and these buds do not unfold for a long time, *i. e.*, till the part of the stem above them has taken a firm hold.

The advantage a creeper derives from this constitution of its tip is evident. It keeps the stem light and movable, and enables it to slide through any hole in the thicket through which it seeks its way up to the light. It has rightly been called the "forerunning tip" of the lianas.

Not all the lianas are *Twining Climbers.* Some climb by sliding with their tips through the branches of other trees and growing "straddling" branches which lean against their supports without actually clinging to them. These climbers are often furnished with spines and thorns which they use to prevent their gliding back. Such *Straddling Climbers* are the Rose (see page 42), the Rangoon Creeper (*Quisqualis indica*), the Bamboo, etc.—Other climbers produce rootlets along their slender stems by which they cling to their supports as by a thousand little fingers. Such *Root-Climbers* are the Pepper vine and many genera of the family of the Aroideæ, *e. g., Pothos scandens* (*Can.* Adkebiḷu; *Mal.* Ānapparuva).—Most climbers, however, develop special organs for climbing, namely tendrils, by means of which they seize their supports. *Tendril Climbers* are the Pea, the Cucumber, the Grape vine, etc.

3. **The Thirst for Light in Plants.**—In the second part of this book (Assimilation) it will be shown why plants require the light of the sun for their growth. The amount of light required is, however, not the same for all plants nor is it the same for the different parts of a plant. Plants generally protect their young buds and shoots against the direct light of the sun, as for instance the Elephant Creeper, by keeping them folded for some time and by a dense coat of hair on the outer side, or as the Mango tree, by providing a red pigment in the outer cells and by letting them hang vertically. This is because intense light destroys the green grains in the cells of the leaves. The glaring light of the midday sun is too strong not only for young shoots but also for grown-up plants, and many of them, therefore, protect themselves against it by folding their leaves at that time (Acacia), others by reflecting it from the shining surface of their leaves (Mango), others again by seeking shelter in the shade of other plants. Thus we find in a forest about 5 different stories in which plants

arrange themselves according to their need of light. The full sunshine is enjoyed by the tree and the lianas at the top. Less light is wanted by shrubs which keep below the trees and by epiphytic plants which perch on the branches and trunks of the trees. In their shade grow herbs and ferns. Below these crouch the mosses and other cryptogams. The lowest and darkest place is occupied by the fungi which require hardly any light leading a parasitical life in the leaf-mould or humus at the bottom of the forest.

4. **Flowers.**—On reaching the top of trees the Elephant Creeper assumes another mode of growth. The tip need now no longer to grow so quickly, for it has brought the plant up to the light. Branches are developed and flowers make their appearance in the axils of the leaves. They are arranged in three-forked cymes. The calyx consists of 5 separate sepals of unequal size, and the corolla of 5 united petals forming a large funnel, light pink at the border and dark violet within. A little above the base of the flower-tube rise 5 stamens of unequal lengths leaving 5 narrow holes at their base, the entrances to a little chamber in which we find the ovary tapering into a two-cleft style that rises to the top of the stamens. Pull the corolla out of the calyx, and you will see the lower chamber at the base of the corolla. The ovary is surrounded and covered by a pad-like body secreting nectar. Butterflies which wish to sip from the nectar must needs thrust their tongues through one of the 5 narrow passages formed by the bases of the stamens, and thus come in contact with the pollen to fertilize another flower when they go to visit it. Towards evening (find the exact hour!) the petals fold up like the folds of a fan, their visitors having also retired. The petals are now plaited as they were in the bud before opening. When it rains the buds seldom open. (Why? Compare Lotus, page 4).

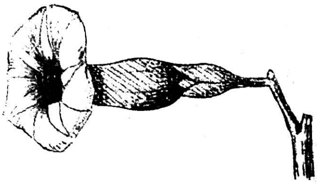


Fig. 68.—Flower of *Argyreia*.

The fruit is a berry with four large seeds.

Other Bindweeds.

Some of the Bindweeds creep along the ground such as the **Sweet Potato** (*Ipomœa batatas—Can.* Sīgeṇasu), the **Goat's-Foot Creeper** (*Ipomœa biloba—Can.* Aḍumbu), and *Evolvulus alsinoides* (*Can.* Vishṇukrānti). Their habits are very much like those of the Cucumber (see page 57). They form, however, unlike the Gourds, adventitious roots at their nodes which property accounts for the mode of their propagation by stem-cuttings.

Others are erect and, like the Elephant Creeper, wind round any support they can reach; such as the common **Garden Bindweeds** *Ipomœa bona-nox, I. coccinea, I. quamoclit,* and others.

The Sweet Potato is cultivated for its tubers which are formed by the side-roots. The leaves of this plant are digitately lobed, perhaps so as to diminish the surface of the leaf to suit the dryness of its habitat. The same may be noticed in *I. quamoclit* (Needle-Creeper), in which the leaf is reduced to a number of needle-like segments.

Pollination is in all these plants effected by butterflies. Ants cannot do it. As they are, however, also fond of the sweet juice in the flower, they crawl up to get something of it. The Sweet Potato, as if by foresight, keeps them off the flowers by offering them nectar from certain glands in the leaf-stalks. *Ipomœa quamoclit* has similar glands on the sepals.

20. The Nightshade Family.

(Solanaceæ.)

Herbs or shrubs, many of which are poisonous. Leaves never opposite, always alternate. Flowers radial. Corolla funnel- or bell-shaped, lobes 4 or 5. Ovary of 2 carpels. Fruit a berry or a capsule.

(*a*) The Potato (*Solanum tuberosum*).

(Plate No. 622.)

(*Can.* Uralagaḍḍe. *Mal.* Uralakiḻaṅṅu. *Tam.* Uralakiḻaṅgu. *Hin.* Baṭāṭā.)

1. **Importance of the Tuber.**—The part of the Potato plant most often seen by us is the *tuber*. This grows in the ground,

but is not the root of the plant. For, if we closely examine the tubers, we shall find buds and also scale-like leaves which never occur on roots, but only on parts of the stem; and we thus see that the *tuber is only a swollen stem growing underground.* If the tubers are planted, new plants will grow out of each of these

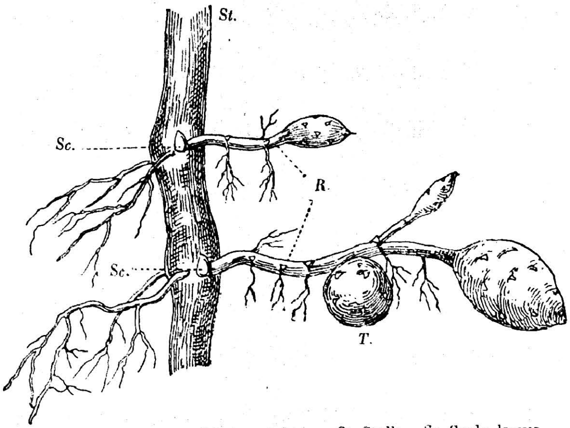


Fig. 69.— Formation of Potato tubers. *St.* Stalk. *Sc.* Scaly leaves. *R.* Runners. *T.* Tubers.

buds. Even if one of the latter is cut out and planted in the soil, it may grow into a new plant. From this it is evident that the tuber is of great importance to the life of the Potato plant.

Let us examine the tubers a little more closely. If we take 2 potatoes of equal size, peel one of them and expose them both to the sun, we shall after some time notice that the one that was peeled shrivels together, whereas the other remains unchanged. The former has lost a great deal of the water it contained. If you plant it—of course, without removing the buds,— no plant will grow out of it, for the buds are withered. So we see that it is the *skin of the tuber* which *protects it from withering.* This skin, we are told, consists of the same substance as cork. And we know that cork is almost the best material available for preventing the evaporation of liquids which are kept in bottles.

Besides, the cork-coat with which the inner part of the tuber is covered, serves as a protection against any hurtful influence from outside. Its bitter taste, for instance, saves the tuber from attacks of insects.

It is by means of these tubers that *the Potato plant can endure the hot and dry season.* At the end of the season the plant is full grown and has formed flowers, fruit, and seeds, as well as a number of tubers under the ground attached to the mother plant by string-like, horizontal runners (fig. 69, *R.*). It will now, for want of moisture in the soil, wither and die down to the tubers which, protected under the ground, preserve the germ of life in their buds. In the following year, when the soil gets moist again, the buds begin to grow just as they do on any branch. The shoot has no roots at first and must, therefore, get all its food from the supplies stored up in the tuber, and this causes the tuber to shrivel up and die as the food stored in it is exhausted. The new shoots in their turn throw out roots and other underground shoots, portions of the latter being filled with starch and swelled

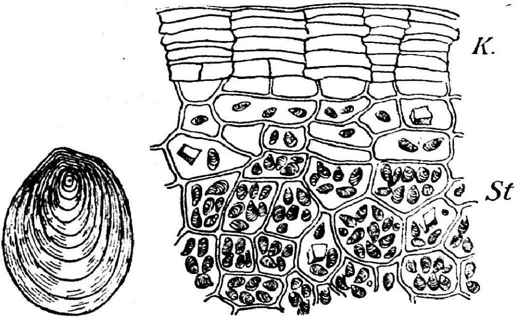


Fig. 70.—Section through the outer portion of a potato. *K.* Cork-cells. *St.* Cells containing starch-grains (140 times enlarged). To the left a starch-grain showing its stratified structure (500 times enlarged).

up to form fresh tubers (fig. 69). As, in their uncultivated state the tubers of the Potato plant remain in the ground and give rise to a large number of new plants, it is of great advantage to

the new generation that the tubers are produced at the ends of runners, and are thus separated from one another.

We see now clearly that the *potato-tuber is* merely *a store of food for the new plant.* This food consists mainly of starch, which is also one of the principal food-substances of man. As the potato-tuber contains no noxious properties and is easily obtained in large quantities, it has become one of the chief vegetables we eat. It is now cultivated nearly all over the world, but does not grow well in the tropics.

2. **Leaves, Flowers and Fruit.**—The stem of the Potato plant does not, as a rule, grow higher than about 1½ feet. The *leaves* are large and feathery or pinnate. But the leaflets are not all of the same size as they are, for instance, in the pinnate leaf of the Tamarind tree. Between the larger pinnæ we find smaller ones. The leaves contain a poison which is also to be found in all other green parts of the plant and especially in the berry.

The **Flower,** like the flower of the Chillies or of the Brinjal, consists of a calyx with 5 segments, a disk-shaped corolla with 5 lobes, alternating with the sepals, and 5 yellow stamens, again alternating with the lobes of the corolla (fig. 71). The large pollen-bags are united at their ends so as to form a cone surrounding the pistil (Plate No. 622, 5 and 7). The anthers open by pores at their upper ends.

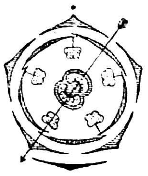


Fig. 71.—Floral diagram of Solanaceæ (*Petunia*).

The **Fruit** is a round, green berry with many seeds in 2 cells (Plate No, 622 6 and 9) which, however, cannot be depended on to produce plants which will give fine tubers. They are, therefore, not used except by nursery men who hope to obtain new varieties.

(*b*) The Tobacco Plant (*Nicotiana tabacum*).

(Plate No. 621.)

(*Can.* Hogesoppu. *Mal.* Pukayila. *Tam.* Pugaiyilai. *Hin.* Tambāku.)

1. This plant has come from America, like the Potato.

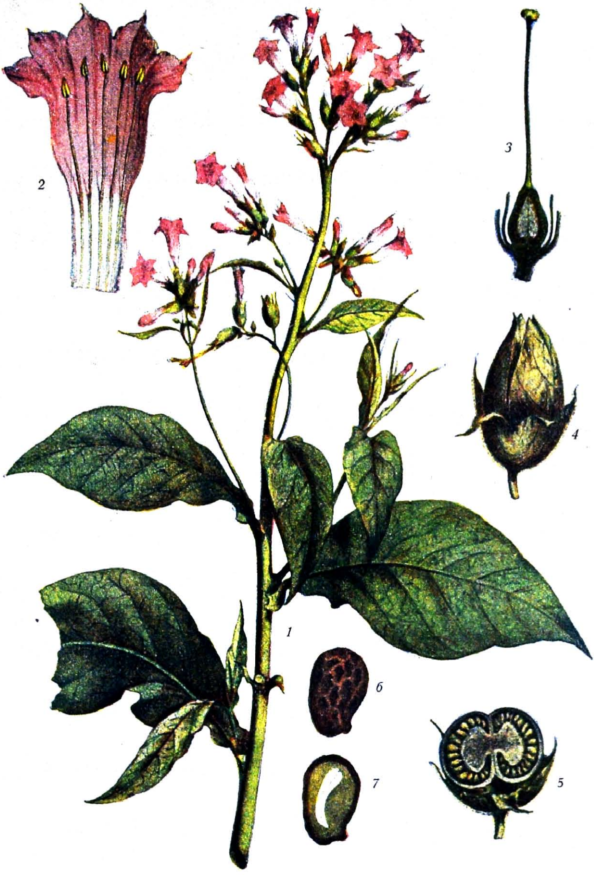


Fig. 72. — Tobacco *(Nicotiana tabacum)*.

2. Flower laid open. 3. Pistil. 4. Ripe capsule. 5. Transverse section of capsule. 6. Seed. 7. Section of it, showing cotyledons and endosperm.

All parts of it are covered with sticky, glandular hairs to keep off animals. The very large **Leaves** decrease in size towards the upper part, thus giving the lower leaves the share of sunlight which they need for the proper exercise of their functions. You will notice, too, that the leaves are almost all bent down at their tips. The plant has a deep, vertically growing taproot with side-roots growing horizontally. The latter, however, do not go beyond the circumference of the leaves and they, therefore, have their tender sucking parts just below the tips of the leaves. We see now clearly why the leaves are bent down. When it rains, all the water does not run along the leaf-stalks to the inner part of the plant, but a great deal flows outwards to where the tips of the roots are waiting for their nourishment (see Mango tree, page 25). The rest goes into the soil, where it is protected from evaporation and can sink in to the deeper lying roots.

2. The stalk bears at its end great bunches of tubular **Flowers**, which are either white or red. The 5 stamens are inserted in the tube of the corolla (fig. 72, 2). The **Fruit** is a capsule formed of 2 carpels (fig. 72, 5). When ripe, it opens in two valves (fig. 72, 4) to let the small seeds escape.

The cross-section of a seed in fig. 72, 7 shows that the 2 seed-leaves are embedded in a separate tissue, called endosperm, which forms a nourishing substance for the plantlet when it begins to grow.

3. In growing the plant for **Tobacco** the stem is nipped off when it reaches a height of about 12 inches and is not allowed to flower. Why? Evidently to aid the formation of the leaves out of the material that might be wasted in the production of flowers and seeds. When the leaves are fully grown, the plant is cut down and left in the field for several days, after which, early in the morning when there is still dew on them, they are removed in bundles of 40 or 50 leaves. If the leaves are too dry and there is no dew on them, water is sprinkled on the leaves before removal. These bundles are then put in a stack where they are frequently re-arranged from top and bottom to middle and from middle to outside. During this process of curing a fermentation by the agency of certain bacteria takes

place. After about two months the leaves are ready for smoking, chewing or making into snuff.

Tobacco contains a poison, called *Nicotine,* of which a single drop suffices to kill a dog. Continuous excessive use of tobacco produces heart and bowel diseases, and can bring on the entire ruin of the body. For children tobacco, taken even in small quantities, is a dangerous poison.

(c) Other Nightshades.

Solanum indicum and *Solanum Jacquinii* (*Can.* Guḷḷa; *Mal.* Vaḷutina), are two very common shrubs, prickly all over. *Atropa belladonna* is poisonous, but a very valuable medicine; it grows, however, only in the temperate zone.

The **Brinjal** (*Solanum melongena*—*Can.* Badane; *Mal.* Vaḷutina; *Tam.* Vaḷudalai; *Tel.* Vaṅkāyi; *Hin.* Baiṅgan) produces the well-known egg-like fruit. Cultivated are also the **Tomatoes** (*Lycopersicum esculentum,* Plate No. 635 — *Can.* Capparabadane; *Mal.* Pētakkāḷi; *Tam.* Erumaittakkāḷi; *Tel.* Takkāḷi). The so-called **Cape Gooseberry** (*Physalis peruviana* — *Can.* Boṇḍuḷa; *Mal.* Moṭṭāmpuḷi) is very common in India. Its calyx is inflated and wholly covers and protects the edible orange-coloured fruit.

The **Chillies** (*Capsicum frutescens,* Plate No. 635 — *Can.* Meṇasu; *Mal.* Pareṅgimuḷakụ; *Tam.* Miḷagāyi; *Tel.* Mirapakāyi; *Hin.* Lālmirči). The scarlet fruits of the Chillies are used as a condiment, and the plant is, therefore, widely cultivated. It is interesting to study the formation of branches. The plant early develops its first terminal flower. Below the flower the stem branches into two forks, each of which produces again a terminal flower, the stem again forking into two branches below it, and so on. The flowers are similar to those of the Potato plant (see page 86), and the fruit is a long, dry berry formed of 2 carpellary leaves. There are a great variety of shrubby Chillies in India. They are generally allowed to stand not longer than one season, as their fruits become very inferior after the first year.

The **Thornapple** (*Datura stramonium* — *Can.* Dattūra, Ummatta; *Mal.* Ummattam; *Tam.* Ummattai; *Tel.* Ummetta)

Fig. 73.—CHILLI PLANT *(Capsicum frutescens).*

is a common weed with a strong, disagreeable smell. Its large leaves are deeply toothed, the two sides generally being unsymmetrical. They are spirally arranged round the stem and its numerous branches, the formation of which is the same as in the Chilli plant. The corolla of the flower forms a large funnel of a pure, white colour. It opens at nightfall and exhales a strong smell which, like the white colour, attracts moths to

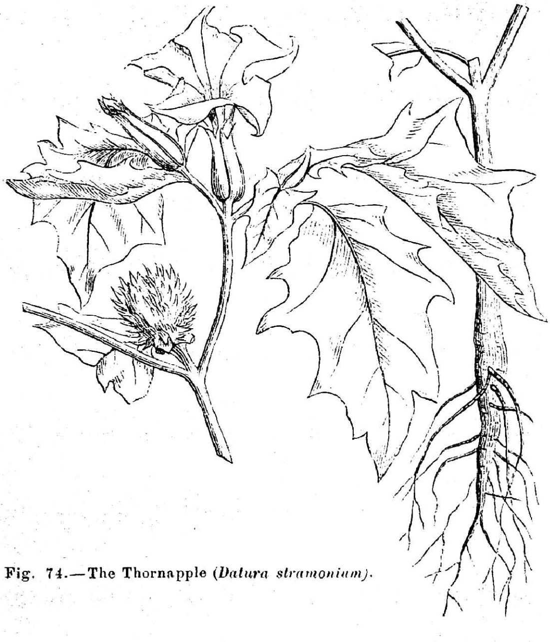


Fig. 74.—The Thornapple (*Datura stramonium*).

transfer the pollen from one flower to another. The capsules, which open in four valves, are covered with many prickles,—a protection for the numerous seeds, which, though they are poisonous to man, are eaten by several birds. These seeds are used medicinally.

21. The Butterwort Family.

(Lentibulariaceæ.)

Carnivorous, aquatic and marsh plants. Flowers zygomorphic. Corolla two-lipped and spurred. Stamens 2. Ovary superior.

The Bladderwort (*Utricularia stellaris*).

The Bladderwort is a little plant with yellow flowers floating in stagnant water and very common in all our tanks and wells. It does not root in the mud nor stretch its leaves above the level of the water like the Lotus and, therefore, has to find some other means of existence.

1. **Absorption of Water and Mineral Food.**—Terrestrial plants suck up water and mineral food by means of their roots. Aquatic plants that are wholly submerged in water absorb water on their whole surface, the epidermis being very thin. Different salts being generally dissolved in water, the plants obtain their mineral food from the water they absorb. This being so, they require no special organs of absorption, and roots are dispensed with. Therefore the Bladderwort cannot exist in running water but only in pools and ponds with stagnant water.

2. **Absorption of Carbonic Acid Gas.**—The bladderwort is green; which shows that it requires carbon dioxide to form starch for its growth. This gas is found in water also, though in very small quantities. To get a sufficient supply of it, the plant has to increase its surface enormously by dividing the leaves into hundreds of parts. Take a potato and cut it into many thin slices: you will see how the surface of the piece is thus greatly increased. The greater the surface of the leaves, the more the area available for absorbing food. The leaves, thus split into numerous thread-like segments hanging down in the water, look like roots (fig. 75).

The air absorbed by the leaves is collected in intercellular spaces which form inflated bags at the base of the branches. These help to diminish the weight of the plant and keep it floating near the surface of the water.

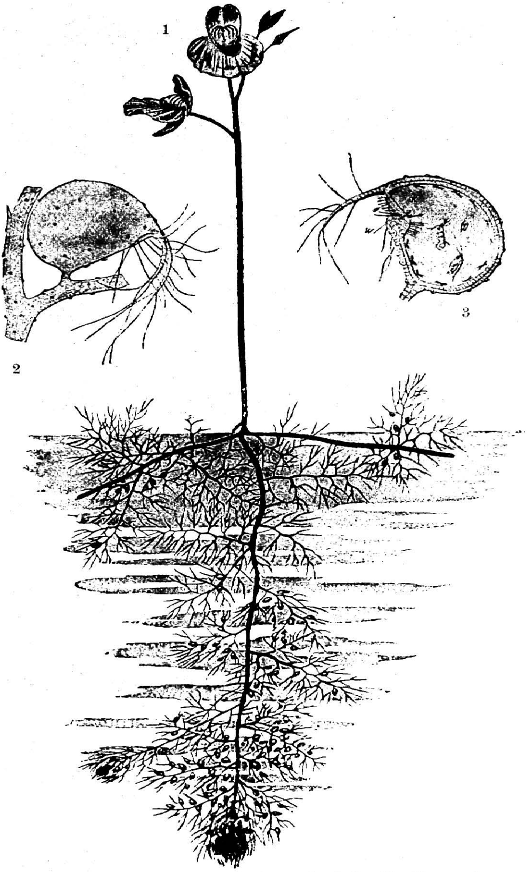


Fig. 75.—1. A flowering branch of the Bladderwort (*Utricularia stellaris*). ½ natural size. 2. Trap as seen from without. 3. Vertical section of the trap (10 times enlarged). *K*. Valve. *W*. Abutment. Two water animals are imprisoned in bladder 3.

3. **Reproduction.**—In order to form seeds the plant throws up little stalks above the level of the water, on which 2—4 yellow spurred, labiate flowers are produced (fig. 75, 1).

When a pool in which Bladderworts grow dries up, they die. Before dying they speedily make preparations to propagate their kind by producing flowers and seeds. But they can do it also in another way: the tips of the branches detach themselves from the parent plant, the leaves folding over the terminal bud; they then sink into the mud to rest there during the dry season and sprout when the pool is filled again with water.

4. **A Carnivorous Plant.**—But the plant leads an extraordinary life not only in so far as it lives in water, but also because it feeds on animal substances. It is a carnivorous plant. To catch its prey it is provided with curious traps, which we shall now examine. If the ordinary Utricularia, which has yellow flowers and is floating in quiet waters, cannot be obtained, the student may find another species of the same genus that grows in every paddy-field. It is a lovely, blue-blossomed twiner, named *Utricularia reticulata,* with a few inconspicuous leaves, which sinks its roots into the soft mud of the rice-field. Take it out very carefully, wash away the mud, and examine it! There you will find little knobs, here and there, of the size of a pepper corn or a little smaller. These knobs are the traps. They are hollow bladders with an opening surrounded by a few hairs, and shut by a valve (fig. 75, *K.*) that opens towards the interior. Little snails and crustaceans that happen to seek shelter in these bladders, can easily enter, guided by special growths at the entrance of the trap, but they cannot get out again and are thus imprisoned, as the valves do not open towards the outer side. After a few days the little animals die, decay and are absorbed by the plant.

5. Many other species of Utricularia are found growing during the monsoon on the rocks. Any of them presents a good type of the **ephemeral** (short-lived) **rock-plants.**

They are usually found in company with the following rock-plants: *Drosera indica,* the **Indian Sundew** (*Can.* Pushpakāsīsa, Kriminā̃sini; *San.* Šiširapatra), belonging to the *Droseraceæ;*

Ramphicarpa longiflora, a pretty small plant, belonging to the *Scrophularineæ,* with leaves divided into many linear segments and with large snow-white, fragrant flowers, opening in the evening;

Eriocaulon sp. (*Can.* Svētaširassu), a small herb with a rosette of grass-like leaves and with a white head of minute flowers (Family: *Eriocaulonaceæ*);

Burmannia coelestis, a very small, leafless plant with 2 or 3 sky-blue three-winged flowers (Family: *Burmanniaceæ*);

Aneilema nudiflorum (*Can.* Nelačaḷu soppu, Saṇṇaguṇḍu hullu), also a small grass-like plant, belonging to the *Commelinaceæ,* with pretty pale-blue flowers on terminal panicles.

These plants find very little food on the rocks and have to

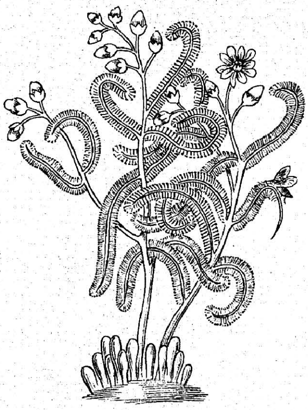


Fig. 76.—Indian Sundew (*Drosera indica*). Natural size.

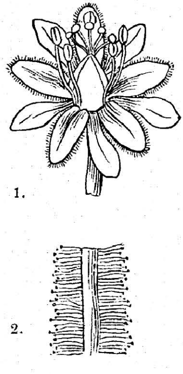


Fig. 77.—1. Flower of Sundew. 2. Glands on the leaves of Sundew (enlarged).

develop their various organs within a few weeks as they cannot live when the rains are over.

The following are their adaptations for a life under such adverse conditions:—

(*a*) Their *seeds* are extremely *small*, they fall into the crevices of the rocks and germinate when the rains begin.

(*b*) The *plants* remain *small* (1—2 inches high) and *grow quickly* producing flowers and seeds in a few weeks, so that all is ended when the rains cease.

(*c*) The want of mineral food is compensated for, at least in some of them, by *animal food.* We have seen how Utricularia catches animals and feeds on them. Drosera or Sundew (fig. 76) is also an insectivorous plant but has other organs to catch insects. The linear leaves of this tiny plant seem to be decked with little diamonds reflecting the light of the sun like little dew drops. There is a sparkling and shining about them like that of the most beautiful brilliant. These sparkling diamonds are little drops of slime, a sticky mass which can be drawn into long threads when touched with the finger—secreted by numerous hairy glands with which the leaves are covered all over (see fig. 77.). What is the use of these glands? A swarm of tiny midges is dancing over the rock. One of them has left its gay society seeking a resting place. The shining drops, seemingly of honey, have allured the animal to alight on the plant. Instantly it becomes aware of its error and tries to fly away. But alas! its legs stick to the gummy liquid, and if it succeed in setting free one or two legs, in the next moment its other parts, head and wings, get again into the fearful slime, and all its desperate struggling has only the result that more glands bend over and fasten on it. This is carried to such an extent that the whole blade of the leaf occasionally doubles over. The whole animal is now covered with the slimy fluid secreted by those glands. It dies, and the soft parts of it are in course of time digested by the liquid which is slightly acid as can be told by testing it with blue litmus paper. After the plant has thus absorbed its animal food, the leaf is unfolded, the hard skeleton of the dead animal soon dries and is carried away by the wind; and the glands shine as before till another careless fly, or a thirsty little caterpillar, or a small butterfly sits on them and runs into death. Larger insects are not caught, as they are strong enough to make their escape from the tentacles of the plant.

22. The Sesamum Family.

(Pedaliaceæ.)

Herbs with opposite leaves. Flowers zygomorphic. Stamens 2 longer and 2 shorter (didynamous). Ovary superior of 2 carpels.

The Gingili or Til Plant (*Sesamum indicum*).

(*Can.* Ellu. *Mal.* Kārellu. *Tam.* Ellu. *Tel.* Nuvvulu. *San.* Tilah.)

1. **Leaves, Flowers, and Fruit.**—The Til is an annual herb cultivated over the whole of India for the oil extracted from its seed. It has opposite, ovate leaves, the lower ones being often lobed. Leaves cannot do their work properly unless they get sufficient light; so while the plant has its lower leaves large and spreading, the *upper ones are* considerably *smaller* and *slant upwards*.

Fig. 78.—The Til Plant (*Sesamum indicum*).

The flowers are large and handsome. The *corolla* is *bell-shaped* and hangs down, protecting the delicate inner organs from rain or dew. As soon as the corolla falls off, the flower-stalk becomes *erect* so that the seed-box can better expose its seeds to the wind. For, if the capsules remained hanging, the seeds could only fall vertically and would not be dispersed. When cultivated, the seeds are, of course, not allowed to drop. Nature provides for the plant growing wild and, therefore, gives it the means of scattering the seed as much as possible.

2. **Accommodation to Conditions.**—The whole plant is covered with woolly hair. This coat of hairs reduces evaporation by interfering with the free circulation of air on the surface of the

leaf, which we shall understand from a little experiment. Moisten 2 sponges of equal size and put them on the same place for drying, but wrap a piece of cloth round one of them. We shall find that the covered sponge keeps its moisture longer than the other. How does this happen? From both sponges water-vapour rises, but the vapour under the cloth cannot escape so freely as from the uncovered sponge, and so the rate of evaporation is slackened. Precisely the same happens with two leaves of which one is glabrous or uncovered and the other hairy or downy. Excessive loss of moisture through the epidermis would cause the plant to wither, as it would not be in a position to make up for this loss by the sucking action of the roots.

The plant wisely accommodates itself to the conditions under which it is forced to live. Plants growing during the rains have generally larger and broader leaves; so also those which grow in the shade. Their epidermis is thinner, and they are less hairy. But plants which grow during the dry season reduce the surface of their leaves to a minimum and protect themselves with a rough, thick, and very hairy epidermis. They are also usually very stunted.

23. The Acanthus Family.

(Acanthaceæ.)

Herbs or shrubs, with decussate leaves. Flowers zygomorphic, generally 2-lipped, bracteate. Stamens inserted in the corolla, either 4 (didynamous), or 2. Ovary superior. Fruit a capsule, containing a definite number of seeds and opening elastically to eject the seeds.

The Sea-Holly, or Bear's Breech (*Acanthus ilicifolius*).

(*Can.* Holeculli; *Mal.* Payiñäculli; *Tam.* Kalutaimulli.)

1. **Habitat and Adaptation.** -- The Sea-Holly is a common companion of the Mangrove trees (see page 46) in the dismal salt marshes which is beautified by its handsome blue flowers. The leaves are shining, spinous and sinuous like those of Holly. Hence the name. The structure of the leaf is xerophilous showing

a thick epidermis and additional layers of cells below the epidermis filled with water (see Mangrove, page 48).

2. **Bracts.**—The leaves next to the flowers are somewhat different from those below. In many plants (Poppy, Mustard, etc.) we have observed a gradual decrease in size of the foliage leaves from below to the top. In some plants the transition is rather abrupt. The leaves immediately below the flowers, thus modified but still resembling the general build of the foliage leaves, are termed bracts. They serve as additional covers of the buds. (See also Cotton, page 11).

3. **Flowers and Pollination.**—The corolla is large and by its bright-blue colour attracts humble bees which, alighting on the broad lip and following the dark-blue lines that lead to the nectary, press their head into the narrow interior of the flower. The nectar is hidden at the base of the floral tube behind the ovary. The filaments bar the way to it. The anthers are inclined to one another and pour out their pollen into the hairs with which the upper part of the filaments is thickly covered. Now, when the filaments are pressed to the side by the head of the bee, the pollen falls from the beard of the filaments on the back of the insect. In another flower which is next visited by that insect the pollen is brushed by it on the stigma of the style overtopping the anthers. Cross fertilization is thus accomplished here by the help of insects.

The seeds are dispersed by an elastic opening of the capsula.

4. The following common plants belong to this large family:

Adhatoda vasica (*Can.* Āḍusōge; *Mal.* Āṭalōṭakam; *Tam.* Āḍadoḍai; *Tel.* Aḍḍasaramu), a common shrub in hedges;

Barleria prionitis (*Can.* Muḷḷugōranṭe; *Mal.* Čemmuḷḷi), growing on the margin of rivulets, and armed with needle-like spines;

Andrographis paniculata (*Can.* Ūrakiriyātu; *Mal.* Nilavēpu; *Tam.* Nilavēmbu; *Tel.* Nelavēmu), a valuable medicine plant;

Thunbergia grandiflora, a beautiful climber with large, blue flower-bells, often grown in gardens;

Meyenia erecta, a common garden-shrub, with blue flowers;

Strobilanthes sp., very common bushes in the forests of the Ghauts, with knotty and smooth stems, brittle like glass, flowering in the 7th (or 12th?) year.

24. The Labiate Family.

(Labiatæ.)

Plants with square stems, decussate leaves, and labiate (two-lipped) flowers. Stamens generally four: 2 longer and 2 shorter. Style one, inserted between the lobes of the ovary, stigma bifid. Fruit of 4 dry, one-seeded nutlets, originating from 2 carpels within the bottom of the calyx. Mostly aromatic plants.

(*a*) The Tumbe Plant (*Leucas linifolia*).

(*Can.* Tumbe. *Mal.* Tumpa. *Tam.* Tumbai. *San.* Rudrapushpa.)

This plant appears with the rains everywhere, near roads, ditches, hedges, and flowers as long as there is any moisture in the ground.

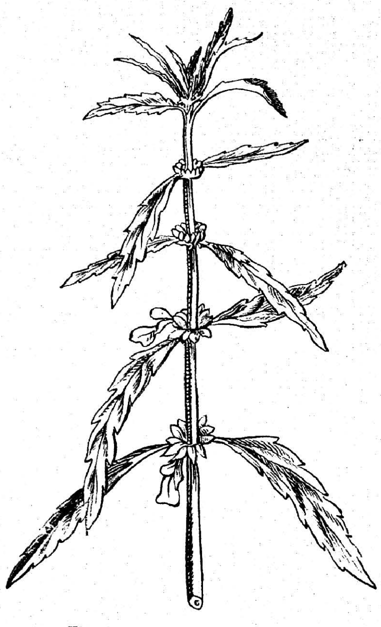


Fig. 79.—Tumbe (*Leucas linifolia*).

1. **Accommodation to Conditions.**—The **Leaves** are linear, serrate, and decussate, *i. e.*, they are so arranged that every pair stands crosswise over the next lower pair. So are also the many branches. This affords it the advantage of the stem being equally loaded.

If we compare Tumbe plants that *grow in moist and shady places* with such as grow in *dry and sunny ones,* we shall find that the former have always larger and more delicate leaves than the latter. We shall learn something from this fact.

Those plants which are growing in the shade of a tree, naturally get less sunlight. Their leaves must, therefore, be larger so as to get a greater quantity of the light that is not so intense. A small amount of the intense sunlight, which can be obtained by the small, nearly linear leaves of the specimens growing uncovered, is more than sufficient for their growth. Further, those in shady and moist places will, if plucked, fade much sooner than the other kind. Why? Since the place where they stood is always moist, they need not be economical with water and their leaves are, therefore, large and tender. They lack the various means of checking the evaporation of water, such as a thick epidermis, a small surface, etc. (Contrast it with Cactus, p. 52.)

The same will be found, if *plants growing on a rich and a poor soil* are compared. The difference in this case is, however, caused principally by the quantity of food the plants are able to extract from the soil; hence the root-system of those growing in the rich soil will be found to be much larger than that of plants which grow in a poor soil.

2. The **Stem** has not only to bear its own weight and that of the branches with their leaves, but it must also be able to resist the bending, twisting, and breaking influences of the wind. If the stem is bent by a rush of wind to one side, the parts on that side of the stem towards which it is bent will be pressed together, whereas the other side will be stretched by the tension exerted on it. The middle part will naturally suffer least (fig. 80). Therefore *the* **sides** *of the stem should be strongest*. Now, if the stem of the plant is cut across (fig. 81), it will at once be seen that this is really the case. There are four bundles of strong fibres at the four corners of the stem which thus becomes quadrangular.

And as every architect is careful to make his work as strong as possible with the least amount of material, so we see here also that the middle part which, as we have seen, has not to contribute anything towards the strength of the stem, remains *hollow* or *filled with soft pith only*.

Moreover, a simple experiment will show that it is easier to break a long tube than a short one. We, therefore, find the

stem of the plant divided into different short pieces by *nodes* at the parts from where the leaves issue. These nodes are solid. The pieces between the nodes are termed internodes.

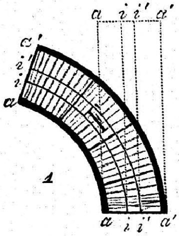


Fig. 80. — Transverse section through a cylinder, straight (with dotted lines) and bent (with thick lines). In the straight cylinder all edges are equally long; in the bent one the inner edge *(a)* is shortened and the outer one *(a')* lengthened.

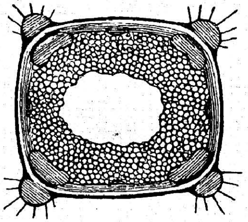


Fig. 81.—Transverse section of the stem of a Labiate plant, *Lamium album* (40 times enlarged).

3. The **Flowers** of the plant should be noted, as they have the typical shape of the flowers of the order to which it belongs (*Labiatæ*). They are arranged in whorls on the nodes of the upper part of the stems. Each flower is short-stalked and sits in a bell-shaped calyx (fig. 82). The lower part of the corolla is a tube which in its upper part deeply *splits into two lips*. The lower lip is broad and forms the conspicuous part of the flower, attracting by its white colour insects, which know quite well that flowers usually contain sweet honey. If you pull out one of the flowers and suck it, you will find that there really is a tiny drop of honey in them. The upper part is smaller and shelters, under its hairy hood or helmet, four *stamens* of which two are a little longer than the two others.

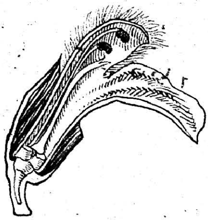


Fig. 82.—Vertical section of the flower of Tumbe (*Leucas linifolia*), only 2 stamens are visible.

If you now put a pencil into the throat of the flower, the stamens will slightly protrude from their sheltered place and rub themselves against the pencil. The same thing happens when a bee or other insect thrusts its proboscis into the flower-tube to fetch the honey. The stamens bend forward and deposit their pollen-grains on the back of the bee, which carries it to another flower where the pollen will fall on the two-cleft stigma, which is at the end of a long style rising from between the four-lobed ovary, and thus fertilize the ovules in the seed-box.

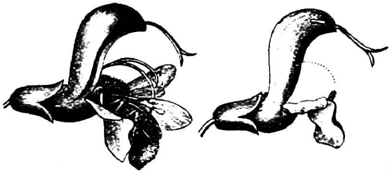


Fig. 83.—Lipflower of *Salvia*, and bee.

The stamens of *Salvia* (fig. 83) have connectives which are pushed back by the visiting insect and cause the anthers to bend down in a large bow.

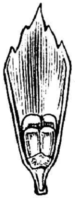


Fig. 84.—The fruit of Tumbe (*Leucas linifolia*). Front part of the calyx-tube removed.

The **Fruit** is composed of 4 little, one-seeded nuts at the base of the persistent calyx (fig. 84). They originate from 2 carpels each containing 2 seeds. When ripe they separate, and the gentlest wind can shake them out of their case.

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(*b*) The Tulasi Plant (*Ocimum sanctum*).

(Plate No. 64.)

(*Can.* Tulasi. *Mal.* Śiva Tulasi. *Tam., Tel.* Tulasi. *San.* Krishnama...

This is a nice little plant which can be seen in front of most Hindu houses. It is a symbol of chastity and modesty. Its structure is very much the same as that of Tumbe. The lips of the small purple flower are, however, a little different. The lower lip is narrow and small, whereas the upper lip is four-lobed, and the stamens project outside.

The *aroma* so characteristic of the plant is due to the presence of an *ethereal oil* secreted by small glandular hairs scattered over

the surface of the stems and leaves. The greater part of this oil, however, is retained by the plant in tiny casks, as it were, in which it is stored at the time of its most vigorous growth to be in readiness for use at a time when the supply of food does not keep pace with its expenditure. This happens when the plant ripens its numerous seeds each of which requires rich food. It can be observed that the aroma of the plant is less at the time of flowering and fructification.

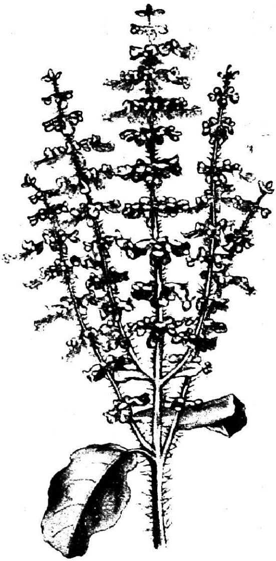

Fig. 85. — The Tulasi Plant (*Ocimum sanctum*).

Plants growing in the shade have much less of this volatile oil than plants growing in open places. The shade compels the plant to enlarge its foliage, and thus necessitates a much larger expenditure of food-stuff, so that much of it cannot be stored up for the future. Such plants do, therefore, not flower so readily as plants in open places.

(*c*) Other Labiates.

This family is but poorly represented in the tropics. They are chiefly found in the northern temperate zone, where they thrive best in a dry, sunny situation like most aromatic plants. Some common Indian species are, besides Leucas and Tulasi, **Sweet Basil** (*Ocimum basilicum*—*Can.* Kāmakastūri; *Mal.* Rāmatuḷasi), and the **Dog Tulasi,** *Ocimum canum.*

"**Lavender** and **Salvia** for their flowers, and **Coleus** for foliage, are old-fashioned favourites in gardens; but perhaps the sweet herbs of the kitchen garden are still better known—**Mint, Thyme, Marjoram, Rosemary, Savory.**"

25. The Verbena Family.

(Verbenaceæ.)

Plants resembling those belonging to the *Labiatae*. The distinction of the 2 families lies in the structure of the ovary. The Verbena Family has a 4-celled ovary originating also from 2 carpels but with a terminal style. Fruit mostly a drupe or a berry.

The Teak Tree (*Tectona grandis*).

(*Can.* Tēgu, Sāgōni. *Mal.* Tēkkụ. *Tam.* Tēkku. *Tel.* Tēku. *Hin.* Sāgvān *San.* Tēka.)

1. **Trunk and Wood.**—The Teak tree is one of the most useful timber-trees of Western India. Its wood, being fairly hard and very durable, is especially useful for ship-building. It also contains an oil which preserves the nails driven into it.

If the trunk is sawn through, a number of concentric circles can be seen. These are found also in most other trees and are called *annual rings,* as one ring is generally formed in a year (fig. 19, page 22). They consist of alternate layers of soft and hard wood. This may be tested with the point of a knife. The soft wood is formed during the rapid and luxuriant growth of the tree during the monsoon, when it is covered with its enormous leaves and there is plenty of moisture, and the leaves are absorbing large quantities of carbonic acid gas from the air. The hard and dark rings of wood, however, represent the cessation of growth during the cold and dry season, when the tree drops all its leaves and stretches its bare branches towards the brazen sky. We can, therefore, estimate the age of the tree by counting its rings; for every dark, hard ring corresponds to a dry season, and every light, soft ring to a rainy season.

Trees of this class (Dicotyledons or Exogens) add wood to their trunks every year. This addition of wood is not made in the centre of the trunk but under the bark. If the bark is stripped off at the time when the tree is growing vigorously, we always find a sticky watery fluid between bark and wood. This is the sap contained in tender cells which are dividing rapidly. The wood on the outside of the stem is lighter coloured than

that in the centre, which is golden yellow when freshly cut. The layers are called *sapwood* and *heartwood* respectively. It is in the outer part of the wood, and not in the old wood in the middle of the tree, that the sap flows up from the roots to the tips of the branches to produce there, together with the food taken in by the leaves, new leaves, flowers and fruits. As new layers are formed one by one every year, the older layers cease to take any active part in the life-work of the tree, and harden. The hardest and most durable wood is the heartwood which being gradually impregnated by the waste products formed in the course of the growth of the tree, becomes denser and denser. A white deposit is also found in cavities in the wood which consists of *Calcium Phosphate*.

2. The **Leaves** of the Teak tree are very large. They are *opposite*, and every pair of leaves stands crosswise to the next pair (decussate). In this way the load of the great leaves is evenly distributed, as in the Labiatae. We can also see that the stems of young branches are quadrangular and channelled, and that they have large quadrangular pith.

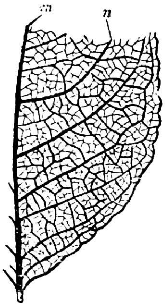

Fig. 86.—Portion of a net-veined leaf. *m*. Strong midrib. *n*. Side-rib.

The leaves are very rough on their upper side. The lower side is clothed with dense, grey hairs. They also show a beautiful *network of veins* or ribs. We can guess why the ribs of these large leaves are so strong. It is, no doubt, because they are so large that they require also a strong frame-work to support them.

The ribs have also other functions, namely, on the one hand to carry the sap which ascends from the roots through the trunk and the branches to the leaf and distribute it over its whole blade, and on the other hand to receive the products of assimilation (starch, etc.) from the green tissue of the leaf and to carry them down through the petiole to the trunk where they are disposed of in such a way as is good for the general growth of the plant. Thus there

is a flow of sap ascending the tree to the extremest parts of its leaves, and another descending from these cells to the trunk. And for these two streams in opposite directions there are also different groups of vessels in every leaf-rib and in the leaf-stalk.

In *the dry season* the *leaves fall down*. And this is a good thing too. For they have such a large surface that the tree would lose too much moisture by them, and would wither and die, if the leaves remained on the branches. (See page 47.)

Preparation for the fall of the leaves is made long before they actually fall. A fine line or ridge may be traced just below the junction of the leaf with the stem. This dark line is in reality a thin transverse layer of cork, which, when the leaves have done their work during the year, taking in stores of nourishment for the benefit of the tree, grows and so detaches the leaf from the stem. It is interesting to note also that the starch which the leaves have been making during their life-period, is not lost with them, but is transferred to the stem previous to their fall, and chiefly stored up just below the base of the leaf-stalk, so as to afford nourishment to the bud which is found in the axil of every leaf.

When they fall beneath the tree, they become leaf-mould (humus), which, in its turn, when fully decayed, restores to the soil a large proportion of the minerals taken from it by the roots of the tree. Note also when the leaves fall and decay, how the soft part between the veins rots first, leaving a beautiful skeleton of the leaf. This can be best obtained by keeping the leaves in water for a month or two.

3. **The Teak Tree a tropophilous plant.**—From the observations we have made above we learn that the Teak is adapted to various conditions of the climate. The Mangrove (page 47), and the Cactus (page 52) are xerophilous in their structure, *i. e.,* they possess various contrivances to check the transpiration of water. Other plants, like the Garden Balsam (page 20), have a hygrophilous structure, characterised by large leaves with a thin epidermis to allow the water freely to evaporate.

The Teak combines the two types. It is hygrophilous at one time, *viz.*, the monsoon, producing large and numerous leaves to

transpire large quantities of water, and growing luxuriantly; and xerophilous at another time, *viz.*, the dry season, diminishing the process of transpiration by shedding its leaves and stopping

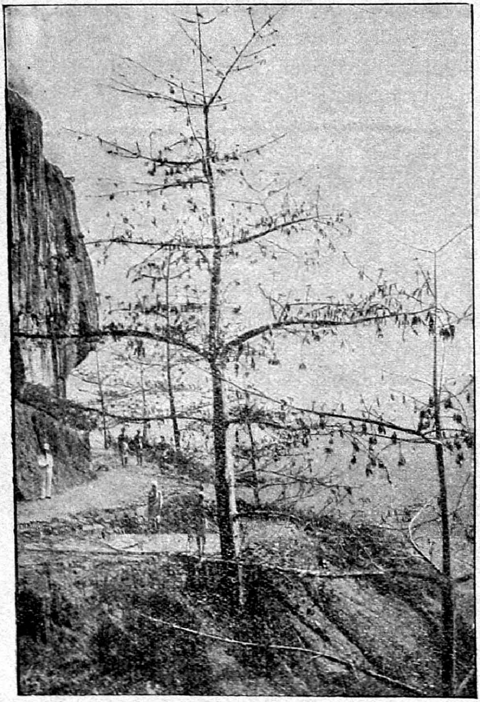

Fig. 87. — The Silk Cotton tree (*Bombax Malabaricum*), stripped of leaves.

its growth. Other trees that shed their leaves in the dry season are the **Silk Cotton Tree** (*Bombax*, p. 12), the **Pagoda Tree** (*Plumiera*, p. 76) and the **Coral Tree** (*Erythrina*, p. 35).

We call such plants tropophilous. The same is observed in most trees growing in cooler climates. There it is during winter

that plants cannot obtain water, because, though there is plenty of it in the ground, it is frozen. And as they can obtain nothing or almost nothing, they cannot spend much. Therefore they shed their leaves in the beginning of winter, and become xerophilous. Water becomes available for them again in spring, so they take on their green and rich foliage in summer and become hygrophilous.

4. The **Flowers** are small, but clustered in large, white panicles overtopping the green foliage, and thus make the tree conspicuous at the time of flowering (compare Mango, page 26). They are white and star-like, the corolla having 5 or 6 equal lobes. The number of the stamens is the same as that of the corolla-lobes. The style is single and has a two-cleft stigma.

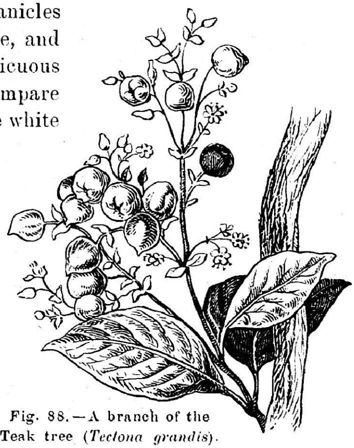

Fig. 88.—A branch of the Teak tree (*Tectona grandis*). Much reduced.

5. The **Ovary** is four-celled and grows under the protection of the inflated calyx into a very hard, bony nut covered with a fur-like coat.

Other Verbenas.

One of the commonest Verbenas is the **Lantana** (*Lantana camara—Can.* Nātagiḍa; *Mal.* Arippu), a straggling shrub with square, prickly stems and pretty orange or pink flowers arranged in small heads. It is a native of America, but has run wild nearly everywhere in India and is a perfect curse to planters by the way in which it spreads in all directions destroying other growth. It is often used as a hedge plant.

The **Chaste Tree** (*Vitex negundo—Can.* Lakki; *Mal.* Indrāṇi; *San.* Nirguṇḍi) is a tall shrub with gray foliage, covered with

silvery down all over, and bearing small, lilac flowers in panicles. The aroma noticed in the leaves of the Labiatæ (page 101) is found also in this plant.

Another very common genus of this order is the **Clerodendron** of which some species have a remarkable contrivance to exclude self-pollination.

To study this we may examine either *Clerodendron volubile,* a common garden-creeper with a white, inflated calyx and a crimson corolla, or *Clerodendron infortunatum* (*Can.* Iṭṭēvu; *Mal.* Peragu).

The latter is a handsome undershrub with decussate, large and cordate leaves. The erect panicles of its white **flowers attract night-moths** not only by their pale colour, but also by their sweet smell which is specially strong by night. If various flowers are compared, it will be seen that some have their four stamens straight and the style bent down, whereas others have the style straight, but the stamens curled. The stamens are straight in flowers that have recently opened (fig. 89, 1), and curled in such as have already been opened for one or two days (fig. 89, 2). Now, a moth that comes for nectar to a newly opened flower cannot but touch the anthers hanging on the long, horizontal stamens, with the lower side of its wings while it soars in front of the flower thrusting its long tongue into the floral tube. Afterwards, when it goes to a flower which opened the previous night, it must touch the style of it and thus bring the pollen of the first flower to the style of the second. There is absolutely no possibility of self-pollination.

1.

2.

Fig. 89.—Flower of *Clerodendron infortunatum.* 1. Position on 1st evening: Stamens straight, style bent back. 2. Position on 2nd evening: Style straight and stamens curled.

As the flower of this plant attracts night-moths to avail itself of their services, so does the **fruit attract birds** by the black colour

of its 4 drupes and the red colour of the calyx which enlarges and reddens as the fruit ripens. The birds eat the fleshy fruit and disperse the seed.

SUB-CLASS 3.—MONOCHLAMYDEÆ.

Plants with a single or no floral envelope (double in some Euphorbiaceæ). Flowers frequently unisexual.

26. The Nettle and Fig Family.

(Urticaceæ.)

Trees, shrubs, or herbs. Leaves generally rough. Flowers minute, monœcious or diœcious, often crowded on a fleshy body, called an involucre. Ovary free, usually one-celled.

The Banyan Tree (*Ficus bengalensis*).

(Plate No. 638.)

(*Can.* Āla. *Mal.* Pēral. *Tam.* Āla. *Tel.* Mariċeṭṭu. *San.* Vaṭah.)

Two peculiarities distinguish the Banyan tree: it has (*a*) very strange roots, given off by the branches and hanging down in the air, and (*b*) flowers that are hidden in globular receptacles, generally called figs.

1. There is hardly any other tree which spreads its **Roots** so wide as the Banyan tree. We have seen that the Mango tree extends its roots in the ground about as far away from the trunk as the branches in the air go. The Banyan tree is not content with so much, it seeks its nourishment in an area which far exceeds the space covered by its crown.

The latter, too, is exceptionally large, as the branches spread horizontally to a great extent. The trunk could, however, not bear this load, if the long branches had no supports. It, therefore, sends down *aërial roots* here and there which enter the ground as soon as they reach it and may become as large as, and similar

to, the parent trunk. The branching crown becomes enormously expanded, and there is formed a large hall of columns, in the shade of which there is sufficient space for a village. This power of forming roots in the air also explains a strange thing, *viz.*, Banyan trees growing on other trees and strangling them. They are not parasitic like the Loranthus on Mango trees, for they do not strike their roots into the tissue of the tree to prey on its juice. What happens is this:—Birds may drop a seed of the Banyan tree on another tree, where it begins to grow as an epiphytic* plant. It forms root after root. These descend the stem of the tree to the ground, become stronger and

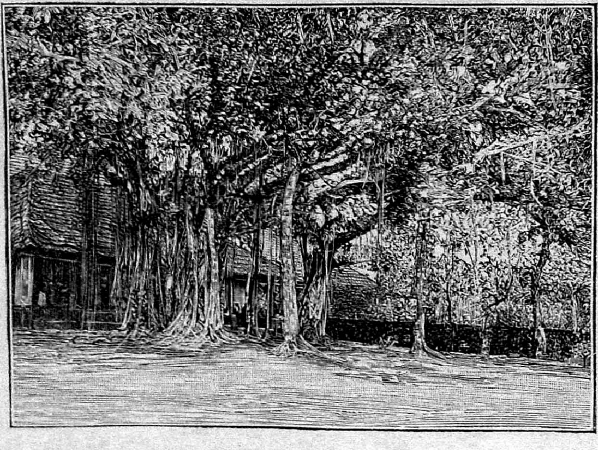

Fig. 90.—The Banyan tree (*Ficus bengalensis*).

stronger, and finally hug it to death. In fact, generally speaking, the Banyan leads an epiphytic life in its youth, and becomes a terrestrial plant only after some years.

2. The large, elliptic **Leaves** of the Banyan tree are downy

* From Greek *epi*, upon, and *phyton*, a plant.

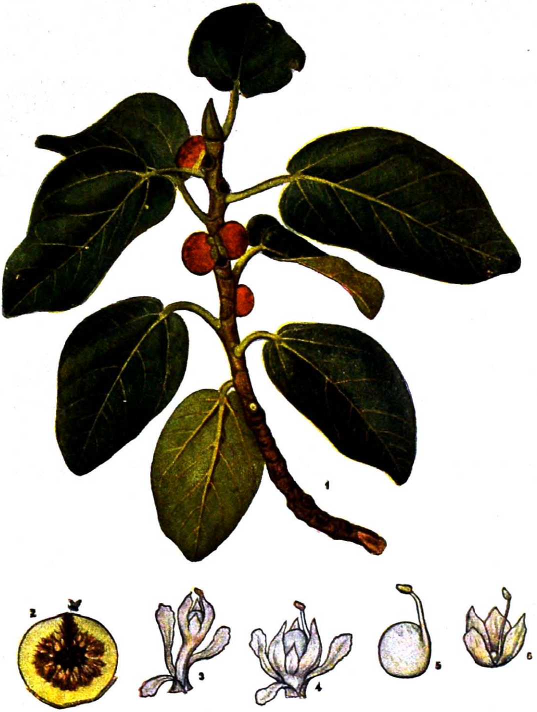

Fig. 91.—Banyan Tree (*Ficus bengalensis*).

1. Flowering branch. 2. Longitudinal section of fig. 3. 4. 5. 6. Single pistillate flowers from within the fig.

beneath, shining above, and covered with a very thick epidermis. They are full of a resinous, milky juice, as are also all the other parts of the plant. All these things work together to make the tree very *hardy* (see Mango tree, page 23).

The *leaf buds* are protected under a sheathing scale, composed of the stipules of the last leaf developed. When the leaves in the bud expand, the stipules drop to the ground, because the plant has no further use for them, and leave an annular scar on the branchlets. In cold countries buds are always shut up in a case of such scales, generally glued together by a sticky substance to shelter them from the weather, especially the low temperature. Although buds sometimes have no such coverings in warm countries, we see them in this plant. They are very useful also for the Banyan tree, for they shelter the buds from withering and drying up during the dry season.

We frequently notice a *red hue on the young leaves* which indicates a very active process of breathing (see Mango, page 24).

The Banyan tree is very hardy and affords admirable shade. It is, therefore, often planted along road-sides. When the leaves have done their work, they fall beneath the tree. At the spot where they were joined to the stem, a fine line can be seen. This is a transverse layer of cells which become corky after the leaf has performed its functions, and cut the leaf off from the plant by intercepting the flow of food and water. The leaves then change their colour from green to yellow and dry up. And as they have now lost their hold of the twig, the wind or a cold night will suffice to bring them down to the ground in showers. The cork layer which grew between the stem and the leaf now affords a protecting covering for the bare place on the stem that is left when the leaf falls off. This bare place is called the leaf scar. (Compare Teak tree, page 105.)

3. It is often remarked by some people that Banyan trees have no **Flowers**. This mistake arises from the flowers being concealed within a fleshy receptacle, which is popularly known from the beginning as the fruit. They are called figs and sit in pairs at the base of the leaf-stalk (fig. 91). If we cut through such a fig, we shall see that there are numerous minute

flowers inside (fig. 91, 2). The round fig, then, is not the fruit of one single flower, like the guava or the pomegranate, but is composed of a receptacle, like that of the Sunflower, with numerous flowers or fruits resting on it. The receptacle, however, is not flat, but forms a hollow ball, leaving a small opening at the top. The little flowers within the fig contain either one stamen or one pistil, each surrounded by a minute floral envelope, called perianth*, with 3 to 5 segments (fig. 91, 3-6). Hence the plant is grouped under the monochlamydeous† plants. The staminate flowers are generally placed at the top of the fig, and the pistillate ones at the bottom. The inconspicuousness of the flowers would point at pollination by the agency of the wind (see II. Part, Pollination). But the fig is *pollinated by insects*. And this is done in the following way.

When we cut figs of the Banyan tree open, we very often find numerous grubs in them and sometimes also little wasps. The latter must have entered through the hole at the top of the fig. They lay their eggs in the ovules of pistillate flowers. In a short time grubs grow from these eggs and eventually become wasps again, and when they leave the fig, they cover themselves with the pollen-dust of staminate flowers near the hole, and thus, when visiting another fig, fertilize the pistillate flowers of the latter. The same happens in the fig of the Cultivated Fig tree (see fig. 94).

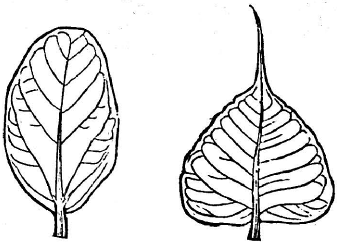
1 2

Fig. 92.—Leaves of 1. Banyan and 2. Peepul.

4. The **Figs** become scarlet and ripen in the cold weather. They are a welcome food for many birds, bats and other animals, which in their turn, disperse the seeds over a wide area.

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* From Greek *peri*, about, and *anthos*, a flower. † From Greek *monos*, single, and *chlamys*, a cloak.

Other Fig Trees and Nettles.

The **Sacred Peepul** (*Ficus religiosa—Can.* Araḷīmara; *Mal.* Arayāl; *Tam.* Aaraçamaram: *Tel.* Rāvičeṭṭu; *San.* Pippala, Açvattha) is one of the sacred trees of the Hindus. The sacred "Bo tree" of Buddha was a Peepul. Its leaves are not roundish, like those of the Banyan tree, but are drawn out in long, narrow points (fig. 92). When it rains we can see that the water drips from these points. And it is good that it is so. Water runs off easier from a point than it would from a blunt end, and the sooner the leaf is dry, the better for the tree. (Why?) Many trees have similarly pointed leaves but none to such perfection as the Peepul tree. The petioles being very long, the leaves

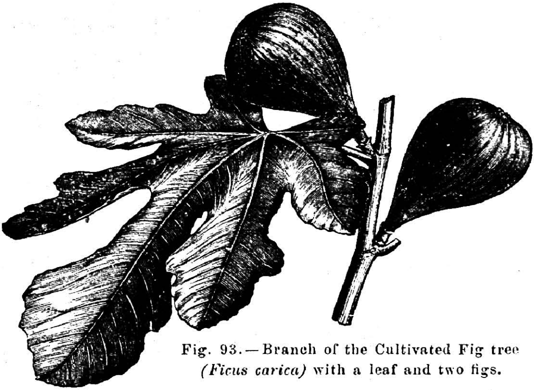

Fig. 93.—Branch of the Cultivated Fig tree (*Ficus carica*) with a leaf and two figs.

are shaken by the gentlest breeze and cause a rustling noise which has given rise to many superstitious beliefs. The tree attains a very great age. The age of a famous Peepul tree at Anurādhapura, in Ceylon, was said to have been 2147 years in 1852, and must be over 2200 years now.—The fruit of the **Country Fig Tree** (*Ficus glomerata — Can.* Attimara) is edible. It grows in dense clusters on the trunk or branches. Its leaves are often covered with galls.

There are many other species of Ficus belonging to India. The most important of the rest is the **Cultivated Fig** (*Ficus carica* — *Can.* Añjūra), whose fruit forms an important part of the food of man and beast in the countries round the Mediterranean Sea where the tree is grown abundantly and produces a superior kind of fruit.

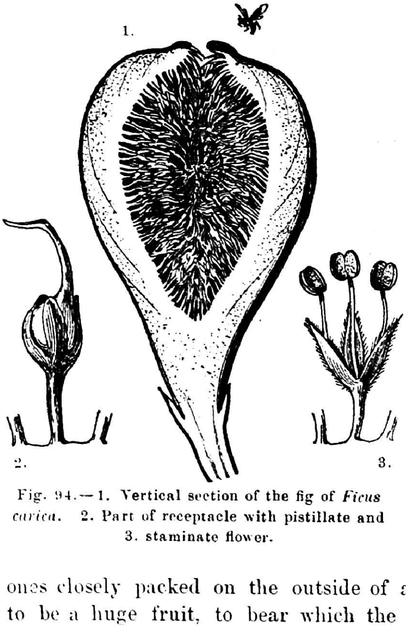

Fig. 94.—1. Vertical section of the fig of *Ficus carica*. 2. Part of receptacle with pistillate and 3. staminate flower.

A very important representative of this family is the **Jack Tree** (*Artocarpus integrifolia* — *Can.* Halasu; *Mal.* Pilāvụ; *Tam.* Palāču; *Tel.* Panasa; *San.* Skandaphala). The male catkins, not much larger than a man's thumb, fall off after flowering, the female ones closely packed on the outside of a long receptacle, grow to be a huge fruit, to bear which the twigs of the tree would not be strong enough; they grow on the trunks and main branches (fig. 95). The immense fruit, the largest edible fruit in the world, sometimes attains a weight of 60 lbs. It is a peculiarity of several tropical trees which grow in such parts of the country where there is plenty of moisture throughout the year, that they have their flowers and fruits not at the ends of their twigs, but on their stems. This agrees with the fact that such trees have also a thin bark through which buds can easily break. They need not form a thick bark as a protection against too great a loss of water by transpiration from the inner parts of the stem.

Other trees that thus develop flowers and fruits from their trunks and branches are, *e.g.*, the Chocolate (page 14), the Bilimbi tree (page 19), and the Country Fig tree (page 113).

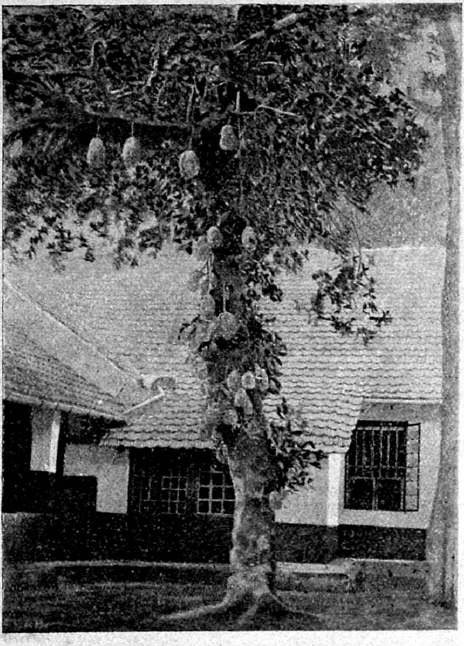

Fig. 95.—A Jack tree (*Artocarpus integrifolia*).

The yellow wood, which darkens after being cut, is used for making ornamental furniture, and the tenacious, white juice of it makes the best birdlime.

An ally of the Fig tree is the **Mulberry** (*Morus indica*—*Can.* Rēshmikambaḷi-giḍa). The fruit of this is, like the fig, a collective fruit, with this difference, that in the Mulberry, as in the Jack fruit, the individual flowers are arranged at the outside of a common receptacle, whereas the flowers of a fig are inside

the receptacle. The leaves of the tree are the food of the silk-worm. It is largely grown both in Asia and in Southern Europe for its leaves and edible fruit.

Another representative of the Nettle family is the **Hemp Plant** (*Cannabis sativa—Can.* Baṅgi; *Mal.* Kañčāvu; *Tam.* Paṅgi; *Tel.* Gañjāyi; *Hin.* Gāñjā). The fibre of the stem of Hemp has been used for ages in the manufacture of rope and cordage, canvas and sackcloth. The plant is a native of Central Asia and has digitate leaves and diœcious flowers, the staminate flowers being on one plant and the pistillate on another. From the green parts of the plant a disagreeable smell proceeds, which can benumb a man. On this depends also the use of the bhaṅgi and gāñjā, a narcotic resin obtained from the Hemp plant. This is either smoked in pipes, like tobacco, or made into a confection and eaten. Preparations of Hemp in use amongst the Mussulmans are called *hashish*. This intoxicant renders men excitable and quarrelsome and disposed to acts of violence. It is from this latter temperament that the use and meaning of our word assassin (*Arab.* haschāschīn = hashish-eaters) have most probably arisen.

27. The Spurge Family.

(Euphorbiaceæ.)

Trees, shrubs, or herbs, usually containing a milky juice. Flowers, as a rule, inconspicuous, unisexual (monœcious or diœcious), often surrounded by bracts. Floral envelope often wanting, sometimes double. Ovary free, usually 3-celled formed of 3 carpels. Fruit capsular and drupaceous; the 3 carpels separate elastically from a central column.

The Castor Oil Plant (*Ricinus communis*).

(*Can.* Auḍla. Haraḷu. *Mal.* Čiṭṭāmaṇakku. *Tam.* Āmaṇakku. *Tel.* Āmudāla. *Hin.* Eraṇḍikējhāḍ.)

The large and glossy leaves of this annual herb are very handsome. They are peltate, which means their blade is fixed to the stalk by a point within the margin. They are also

divided into hand-like lobes and have serrate edges. The flowers are arranged in terminal panicles. They are monœcious, *i.e.*, one flower contains either stamens or pistils alone, and both

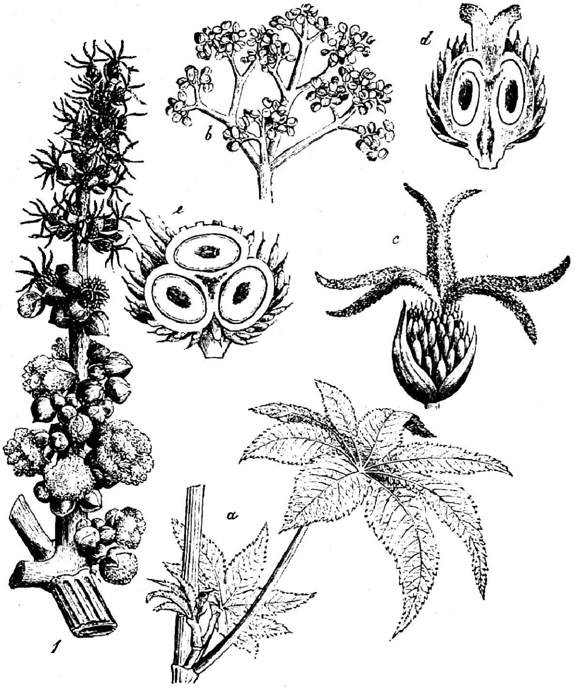

Fig. 96.—The Castor Oil Plant (*Ricinus communis*). Branch with male and female flowers. *a*. Leaves. *b*. Stamen. *c*. Female flower. *d*. Longitudinal and *e*. transverse section of fruit.

occur on the same plant. The staminate flowers are below, the pistillate above. The flowers have one envelope, consisting of 3 to 5 sepals which protect the inner organs when in bud. The structure of the stamens is quite out of the common. They are branched so that a single stamen looks like a bunch (fig. 96, *b*).

The female flowers have 3 styles, each deeply split into 2 segments. The fruit is a spinous capsule with 3 divisions containing one oily seed each. The oil is stored by the plant in the seed as food in reserve for the young plant to grow, just as starch is stored in the Bean (see page 35). But whereas in the Bean the storage is made in the seed-leaves, it is here stored in a separate tissue, called endosperm. A valuable drug, Castor oil, is obtained from the seeds. The capsule opens spontaneously when ripe in the way which is characteristic of the order: The 3 carpels, constituting the capsule (fig. 96, *e*), separate elastically from a central column and split almost to the base.

The oil extracted from castor-seed is also highly valued for lubricating machinery, for dressing tanned hides and skins, for lighting, for soap and candle-making and other arts. Castor-cake is the best vegetable manure in use. The plant is largely grown in some parts of India.

Other Spurges.

Many Spurges (*Euphorbiaceæ*) have an acrid juice in their stems and leaves. If a wound is made, this juice flows out freely. It is often white like milk, but poisonous. Cattle, therefore, do not touch these plants. The juice contains a kind of resin which is sticky and curdles soon and consequently closes a wound instantly, thus preventing bacteria and spores of fungi entering the plant and causing disease or death. It is also a means by which the evaporation of the sap in the plant is slackened.

Some Spurges are exceptionally well adapted for life in the driest and poorest soil.

The **Milk Hedge** (*Euphorbia nivulia—Can.* Kaḷḷi), for instance, has no leaves during the greater part of the year, but cactus-like, succulent stems with prickles in which moisture is stored up (fig. 97).

The following are common types of plants belonging to this order:—

The **Awla Tree** (*Phyllanthus emblica—Can., Mal., Tam., Tel.* Nelli; *Hind.* Aunlā), a tree with numerous horizontal branches and branchlets. The latter look like the ribs of pinnate leaves

but must be considered as branches as they bear flowers. The succulent fruits are eaten or made into preserves, and, if dried when unripe, are used for tanning. The wood is hard and durable, particularly under water, but never grows to a large size. The bark is strongly astringent and can be employed to tan leather.

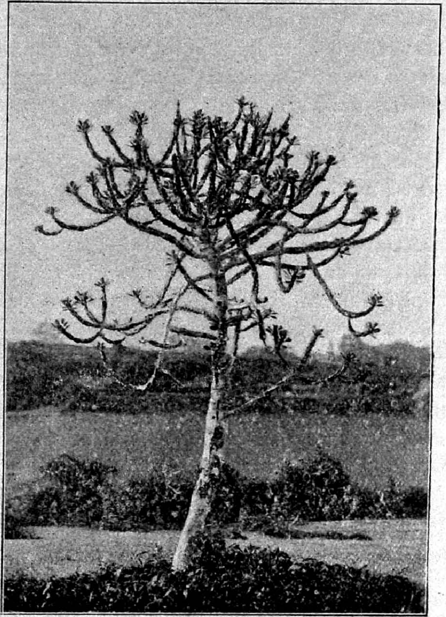

Fig. 97.—*Euphorbia nivulia.*

The **Purging Nut** (*Jatropha curcas* — *Can.* Aḍaluharaḷu; *Ml.* Kāṭāmaṇakkụ; *T.* Āḍaḷai; *Tel.* Adavi-āmudamu) a large, unornamental shrub, much used for hedges. The seeds, taken internally, act with great violence as an emetic and a purgative.

The **Crotons,** mostly originated from *Codiæum variegatum,* also belong to the Spurges. They are to be seen everywhere in gardens, where they are grown for their variegated leaves.

Among the many other species of this large family we must still mention some which have become highly useful. These are the **India Rubber Trees** *Hevea brasiliensis* and *Manihot Glaziovii.* The former yields what is known as Para rubber and the latter Ceára rubber. The rubber is obtained from the milky juice of these trees. One of the ways by which rubber is made is the

following: A number of slanting incisions are made in the bark. Little tin cups are then fixed below the incisions, from which the sap flows into the vessels. The sap remains liquid in the vessels. In order to dry it, clay moulds or planks are dipped into the liquid and then exposed to the sun, or kept in the smoke of wood fires. The thin layers of the liquid, which sticks to the moulds, now dry quickly; and by repeating the same process over and over again, more and more layers are formed until a large mass is obtained. The valueless moulds are broken or the rubber cut off the planks.—This substance, rubber, owes its usefulness to its elastic and waterproof properties. By mixing the raw material with a little sulphur it becomes "vulcanised", retaining now some of its elasticity at a high or a low temperature. It is used for manufacturing tubes, waterproof coats, shoes, balls, toys, and many other things. If, however, equal parts of rubber and sulphur are mixed, a hard, horny substance, called vulcanite, is produced, which is made into combs, buttons and a hundred other things. Rubber is a bad conductor of electricity and is, therefore, much used in making electrical apparatus, for instance, for wrapping round wires of the cables which are laid from continent to continent under the ocean.

28. The Birthwort Family.

(Aristolochiaceæ.)

Climbers. Flowers zygomorphic, perianth tubular, anthers six, sessile, inserted round the base of the stigma. Ovary inferior, of 6 carpels.

The Indian Birthwort (*Aristolochia indica*).

(*Can.* Īsvara-bēru. *Mal.* Perumarunnu. *Tam.* Īsuravēr. *San.* Ahigandhā.)

This is a smooth climber, growing in the thicket of jungles. The leaves are pretty large and their petioles serve as tendrils in support of the winding stem.

The flowers that rise in the axils in small racemes exhibit a peculiar structure. The dark green perianth is tubular forming a globular cavity at its base and a brown tongue at its upper

end. If we split the tube open, we find in the kettle-like cavity the broad end of the pistil crowned with a six-lobed stigma. Round the base of the stigma there are 6 sessile stamens. In fresh flowers we find bristles in the narrow floral tube pointing downwards to the cavity.

Such a peculiar flower can be pollinated only in a peculiar manner. Small midges attracted by the smell of the flower enter into the cavity. If they come from other (older) flowers, they bring pollen with them and brush it against the stigma which in Aristolochia ripens before the stamens. The juicy walls of the prison in which the insects are caught give them nourishment. After about 2 days the stigma shrinks but the anthers at the base of it open and let the pollen fall. The insects are now powdered over and over with the pollen when they move in their little trap. Simultaneously the hairs in the narrow tube which hitherto prevented their escape, begin to shrivel and allow the insects a passage out. The insects, now crawl out of their prison and visit another flower. The pollinated flower, however, now covers the entrance into its cavity by laying the tongue-like limb right over it, in order to prevent insects from visiting them again.

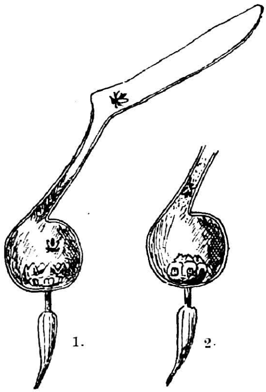

Fig. 98.—Longitudinal section of flower of Aristolochia. 1. Before pollination, 2. after pollination.

"In some American species, one or two of which are grown in Indian gardens, the perianth is almost large enough to form a bonnet for a child." Oliver.

An allied family is the *Nyctagineæ* with two well-known garden species, namely, the Marvel of Peru, *Mirabilis dichotoma,* which opens its flowers at four o'clock, and *Bougainvillea spectabilis,* a spinous climber with inconspicuous flowers surrounded by large carmine bracts often erroneously taken for the petals.

29. The Laurel Family.

(Lauraceæ.)

Aromatic trees and shrubs. Leaves gland-dotted. Flowers radial. Perianth tubular consisting of 2 × 3 leaves. Stamens in 2 or more whorls of 3 leaves each, filaments flattened, anthers opening by valves. Ovary of 3 carpels, one-celled. Fruit a drupe.

The Cinnamon Tree (*Cinnamomum zeylanicum*).

(Plate No. 632.)

(*Can.* Dālcini. *Mal.* Karuva. *Tam.* Lavaṅgapaṭṭai. *Tel.* Lavaṅgapaṭṭa. *Hin.* Dālcīn.)

The Cinnamon tree grows wild in the Malay peninsula and is cultivated in Ceylon for its bark which is a very valuable spice. A variety of it, *Cinnamon iners,* is very common on the Ghauts and on the Malabar Coast.

Fig. 99.—Flowering branch of the Cinnamon tree (*Cinnamomum zeylanicum*).

1. When we rub its **Leaves,** a fine aroma is produced, caused by a volatile oil contained in them. The same oil occurs also in other parts of the tree and chiefly in the inner part of its bark.

The *young shoots* of the tree are often of a *dark crimson* (Plate No. 632, 2), especially in trees growing on high mountains. In the description of the Mango tree (page 24) we have already learnt that this is an indication of active breathing in the young parts of a plant. We can artificially produce the reddening of leaves by wounding them, for by doing so we

increase the action of breathing, by which the plant seeks to heal the wound. (Compare the increase of breathing by which fever is accompanied.) The vigorous process of breathing increases the heat produced by the oxidation of carbon, which naturally benefits a plant growing in the cool climate of higher elevations.

At the same time the red tint in the cells of young leaves may protect the chlorophyll-granules from the destroying effect of too intense light.

Another characteristic of the Cinnamon leaves are the three conspicuous parallel ribs running from the base to the tip (fig. 99).

2. The greenish **Flowers** are seated on terminal panicles. The perianth is composed of 2 united whorls of 3 petals each. The staminal leaves are arranged in 4 whorls of 3 leaves each alternating with one another the 3 outer whorls producing fertile stamens with 4-celled anthers opening by valves, and the inner whorl forming a nectary of 3 arrow-shaped staminodes.

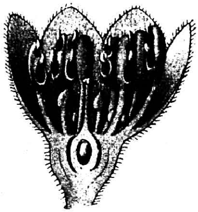

Fig. 100.—Flower of Cinnamomum (longitudinal section).

3. The **Bark** of the tree is aromatic and has become a very important and valuable article of commerce. The bark of branches, two or three years old, is the best. They are then of the size of an ordinary cane. The branches are cut, stripped of their leaves, after which the bark is peeled off with a knife. After removing the outer part of the bark which has a very bitter taste, the inner part of it is carefully dried, when it turns brown and curls up into little rolls.

Why is the whole branch cut when only the bark is wanted? Would it not be more economical to take away the bark and allow the branch to grow and add new bark for another time? As we know from our lesson on the Teak tree, the sap of the tree circulates in the inner layer of the bark and in the outer layer of the wood. If these are destroyed, the circulation from the root to the branches is stopped, and the branch must die. We

could not possibly, therefore, expect the branch to grow after taking away its bark.

4. Allied Plants.

The **True Laurel,** *Laurus nobilis,* is a plant of the temperate zone. Camphor is obtained from *Cinnamomum Camphora.*

To this family belongs also *Cassytha filiformis* (*Can.* Bēḷubaḷḷi; *Mal.* Ākāçavaḷḷi; *Tam.* Kottān; *Tel.* Pāčitīge). This is a leafless, yellowish-green twiner that runs over hedges in a tangled mass. If we examine it, we find that it has no roots in the ground (hence the vernacular names!), but that there are swellings in the thread-like stem wherever it comes in contact with the plant on which it is climbing. From these swollen parts roots come out which break through the bark of the host, from which the guest sucks up its nourishment. Such plants are called parasites.*

30. The Mistletoe Family.

(Loranthaceæ.)

Parasitic shrubs. Leaves often fleshy. Petals 4—8 free or united. Stamens as many and opposite to the petals. Ovary inferior. Fruit a berry or drupe.

The Loranthus *(Loranthus longiflorus).*

(*Can.* Bandaṇige, Badaṇike. *Mal.* Pulluṇṇi.)

1. **Habitat.**—It is commonly observed that certain plants grow on trees, having leaves and flowers different from those of their hosts, growing out of their branches like twigs, as if they were grafted on them. The vernacular names, generally given to these plants, mean what in English is called *parasite.** Parasitic plants insert their roots into the stems of the plants on which they settle and derive their nourishment from the juice of the host.

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* From Greek *para* beside, and *sitos* food.

Parasites must be clearly distinguished from *Epiphytes.** The latter settle also on branches of other trees but have their roots only on the surface of their bark providing their food for themselves. Such plants are, *e. g.*, *Philodendron sp.*, *Ficus sp.*,

Fig. 101.—Epiphytes on a tree: *Philodendron cannæfolium*, and *Ficus sp.*

some Orchids, many mosses and some ferns, such as the gigantic *Polypodium quercifolium* with its oak-leaved scale over the bearded rhizome.

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* From Greek *epi*, upon, and *phyton*, a plant.

2. We may ask, *how* the *Loranthus* bush finds its *lofty place.*—This is due to the agency of birds, which are fond of its juicy berries. There is a clammy substance adhering to the seeds, so that when birds eat the berries, the seeds often stick to their beaks. These they carry about until they happen to rub their beaks on a branch to which the seed then sticks. There it germinates, the tiny root making its way into the soft bark until it comes to the hard wood-cylinder in the interior of the branch through which it cannot pierce. Side-roots are then developed which creep along the wood and below the bark sending out additional vertical roots into the interior (fig. 102). As the host grows, these roots are covered by new layers of wood, so that, in course of time, the roots of the parasite appear to be in the very centre of the branch and to be fused with the wood tissue of the host.

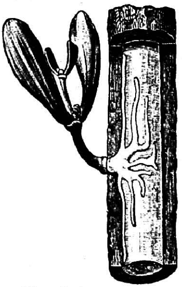


Fig. 102.—A young Mistletoe (*Viscum album*) the roots being laid bare.

3. **The Loranthus a Water Parasite.**—Now, the woody tissue of a tree is the channel for the ascending sap (see II. Part, Stem). And it is, therefore, the ascending water and its mineral ingredients which the Loranthus takes from the host. Other nourishing substances, such as sugar, starch, albumen, are conducted in vessels that are in the inner bark of the tree. The Loranthus does not feed upon them but prepares them by itself. And for this purpose it requires green leaves like other plants.

Notwithstanding this fact, the Loranthus destroys the host. As we have seen, it interferes with the flow of sap in the woody tissue of the host. Accordingly the host is weakened, and not infrequently the branch is killed by the intruder. If the parasitic bush is only cut off, the roots lying in the tissue of the host will sprout again. The only remedy to save the tree is to cut off the branch below the place where it is attacked.

4. Many other parasites feed not only on the ascending sap of their hosts but grow entirely at their expense, taking water, starch, albumen and every kind of food they require from their

host. Such plants need no longer develop any organs to absorb raw food from the air and, therefore, dispense with leaves. In Cassytha (page 124) we have met with such a *holoparasite* *.

On the other hand there is still another category of parasites which we may call *hemiparasites* † of which the Sandalwood tree, *Santalum album* (*Can.* Śrīgandha mara; *Mal.* Čandana maram), is an example. This tree has roots of its own in the ground and develops green foliage like ordinary trees. Yet it is a parasite. When its roots come into contact with roots of other plants, they attack them and suck food from them. This explains a curious fact which is observed now and then: the growth of a Sandalwood tree is affected when a tree in its vicinity is felled, which shows that the Sandalwood tree has lost a source of its nourishment.

31. The Pepper Family.

(Piperaceæ.)

Aromatic herbs or shrubs. Flowers achlamydeous, minute, in catkin-like spikes. Ovary one-celled.

The Pepper Vine (*Piper nigrum*).

(*Can.* Oḷḷēmeṇasina-baḷḷi. *Mal.* Kuru-mulagụ. *Tam.* Milagu. *Tel.* Sāvyamu. *Hind* Kālā-miriči.)

1. This is a large **Climber** requiring the support of other trees. It climbs, however, not like the Bean by winding round its supporter, or like the Cucumber by using tendrils for this purpose, but with the help of small roots which grow from the swollen nodes of the slender zigzag stems. They wind round their support like little cords and contract after some time so that the climber is drawn close to the tree and fastened to it as with a thousand little fingers. They do not penetrate into the tree, and hence the Pepper vine is not a parasite. Besides these adventitious roots, the Pepper vines have, like ordinary plants, proper roots in the ground. If these are cut, the plant withers, unless, on its way up the tree towards the light, the plant has found nourishing earth in the crevices and holes of the tree.

* From Greek *holos*, whole. † From Greek *hemi*, half.

2. The **Leaves** are ovate, entire, dark-green on the upper side and lighter on the lower one. Five or seven ribs along the leaf stand out very prominently at the lower surface. The leaves are placed alternately and grow from the nodes of the stem.

3. **Flower and Fruit.**—When the plant has ascended the tree and so reached a point where it gets more light, its stem leaves the trunk of the tree and produces no more adventitious roots, but forms flower-buds opposite the leaves. The flowers are arranged on densely clustered, hanging spikes, and are very small without any regular calyx or corolla. They are unisexual, *i. e.,* bear either stamens or pistils, but not both together. Besides, one plant has only staminate and another only pistillate flowers. Such plants are called diœcious. The staminate flowers have two stamens, the pistillate flowers one ovule which grows into a berry and becomes red when ripe, containing one seed in a hard shell embedded in its pulp.

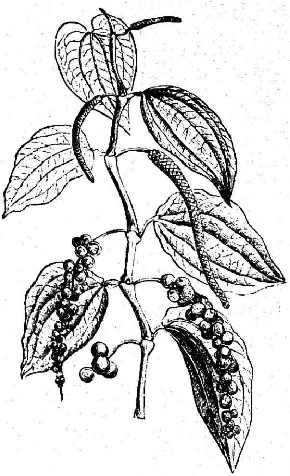


Fig. 103.—The Pepper Vine (*Piper nigrum*).

4. **Use.**—The plant is grown for the fruit which is used as a condiment. Black pepper is the unripe, dried berries; white pepper, the same allowed to ripen, with the pulpy coat removed. The pungent taste and smell of the pepper corn is due to an aromatic oil. The same substance is also noticeable in its leaves, but to a lesser degree.

The propagation of the Pepper Vine is effected by means of mature branches. These are layered, *i. e.,* bent down into the ground, and when they take root, they are severed from the parent vine, planted out in shade, and trailed on to trees.

5. A near ally of the Pepper Vine is the **Betel Leaf Pepper** (*Piper betle* — *Can.* Vīḷyada-baḷḷi; *Mal.* Tāmbūlam; *Tam.* Vetti-

laikkoḍi; *Tel.* Tamalapāku; *Hin.* Pān). Its leaves are chewed with lime and the nut of the Areca Palm.

Peperomia portulacoides is a small epiphytic plant common on the Ghauts.

CLASS 2.—MONOCOTYLEDONS.

Plants with one seed-leaf. Leaves usually parallel-veined. Floral parts generally in sets of 3. Stems not separable into pith, wood and bark, but consisting of fibro-vascular bundles, irregularly imbedded in cellular tissue with a firmly adherent rind outside.

32. The Palm Family.

(Palmaceæ.)

Stem woody, unbranched. Leaves pinnately or palmately divided. Flowers radial, in panicles or spikes. Perianth usually six-leaved in 2 whorls, stamens 6 in two whorls. Ovary of 3 carpels, usually one-celled. Fruit a drupe with a fibrous covering.

The Cocoanut Palm (*Cocos nucifera*).

(Plate No. 637.)

(*Can.* Teṅgina-mara. *Mal.* Tēṅa *Tam.* Teṅgu. *Tel.* Teṅkāyičeṭṭu. *Hin.* Nāralkejhāḍ. *San.* Tṛinarāja.)

The Cocoanut Palm is a tree found only in tropical countries, and there grows best near the seacoast.

1. Its slender, cylindrical **Stem** and the tuft of leaves with which it is crowned, is so different from the appearance of other trees that every one at once understands that the Cocoanut Palm belongs to a class of plants quite different from that which most other trees belong to.

2. **Monocotyledons and Dicotyledons compared.**—A general comparison of the Cocoanut tree with, for instance, a Mango tree will make the characteristic features of the new class, called

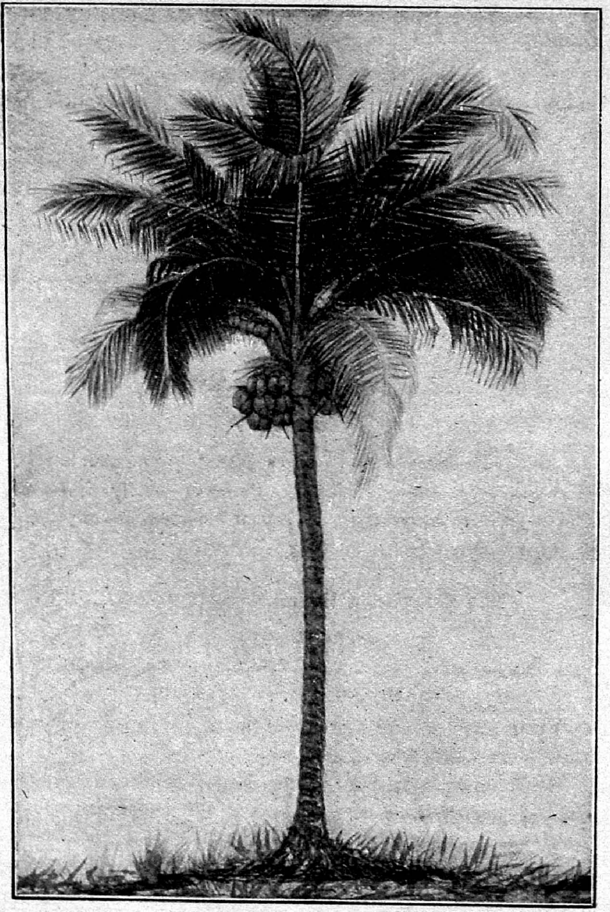


Fig. 104.—The Cocoanut Palm (*Cocos nucifera*).

Monocotyledons, clear and impressive. Beginning with the *root,* we find that the Mango tree has thick and stem-like roots with numerous ramifications, whereas the root of the Cocoanut Palm consists of numerous, similar, thread-like or fibrous roots.

The *trunk* of the Mango tree is stout, grows thicker and thicker as it grows older, and is at a certain height divided into many branches. The stem of the Palm tree is slender, does not increase in girth as it grows older, and never branches. The latter fact explains why the stem need not grow in girth, for it has not to bear such a great load as the Mango tree. A closer examination of the structure of the stem will show that there are no annual zones in the wood-tissue, but that the substance of the stem is like a bundle of sticks closely bound together (fig. 105). The outside of the trunk is not covered with *bark,* but consists only of the very hard outer layer of the wood itself. Young stems of monocotyledons have an epidermis, *i. e.*, a thin cellular coating like that of leaves. The absence of the bark proper suggests that there is not such a thing as the cambium ring in the stem of the Palm tree. The sap circulates in vessels distributed in small bundles throughout the stem which can be plainly seen on the cross-section of a Cane. The cellular tissue of the inner part is looser and contains fewer vascular bundles than that of the outer part, which, with its densely packed ring of bundles, protects the inner part from damage, evaporation and changes of temperature. Many plants of this class, *e. g.,* the Bamboo and other Grasses, have even hollow stems.

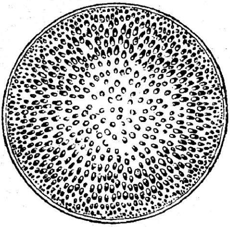


Fig. 105.—Transverse section of a monocotyledonous stem.

The name "monocotyledons", by which this new class is known and to which the Palms, Lilies, Grasses and Orchids belong, refers to another peculiarity of theirs, namely to the fact that their *seeds* develop at first one leaf only, forming a sheath around the leaves of the plumule, whereas the plants that fall under the class of dicotyledons, have 2 such seed-leaves.

There are a few more points that characterise the monocotyledons among which we will mention only these:—

Their *leaves* are generally parallel-veined, and the *floral leaves* are mostly in sets of three, whereas the dicotyledons have net-veined leaves and the floral parts in sets of 4 or 5.

3. **Leaves.**—We have seen that in the Cocoanut Palm a crown of mighty, feathery leaves waves on a slender stem, which can reach a very considerable height. The wind is, therefore, able to exercise its full force on the leaves. These are exceptionally large, sometimes 16 feet long, and if their blades were entire, as they are, indeed, in their undeveloped, folded bud-state, the wind would certainly tear them into pieces or uproot the whole tree. To prevent this and to enable them to withstand the strongest storm, they become slit into segments by the rupture of the tissue at the edges of the folds, forming *pinnate*, *i. e.,* feathery leaves which let the wind pass between the pinnules and so lessen its pressure. Besides, the leaves are covered with such a *strong and hard epidermis* that no vehemence of the lashing tropical rains can do them any harm.

The tuft at the end of the stem contains 12 to 24 leaves. As generally *every month one leaf is produced and one is dropped,* the number of them does not increase. The fallen leaves leave a scar on the stem, by counting which the age of the tree may be estimated.

4. **Cultivation.**—Cocoanut trees are commonly planted in deep pits when they are 1 or 2 years old. It is several years before the tree grows to any height. During these first years the trunk is formed till it attains its ordinary width. At the same time, the leaves enlarge one by one until they have approximately the size of those of full-grown trees. Numerous fibrous roots are being produced to fix the tree firmly in the soil. When it has thus gradually attained the size of a full-grown tree as regards the girth of the trunk and the tuft of leaves, it at last begins to raise itself, and henceforth ceases to grow in width. By planting it in a pit a strong hold in the soil is secured. Later on adventitious roots spring from the trunk higher up, holding the tree like the ropes of a flag-staff. The pit is filled up and disappears.

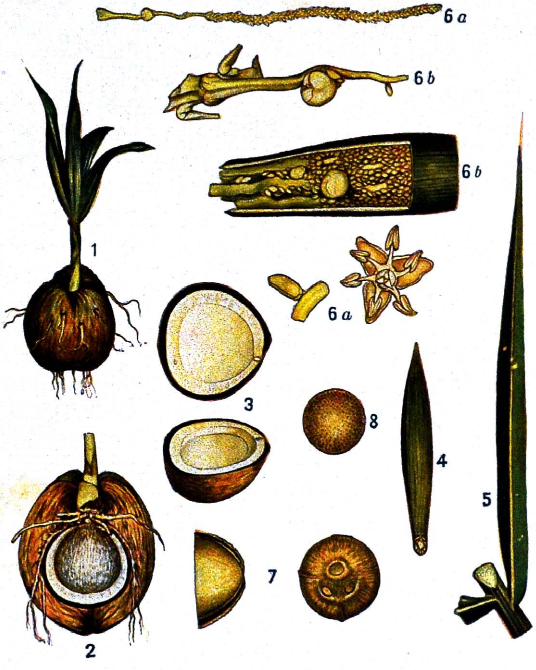


Fig. 106.— COCOANUT *(Cocos nucifera).*

1. Young plant. 2. Vertical section of germinating nut. 3. Ripe cocoanut cut open. 4. Spathe. 5. Pinnule. 6. Flowers, *a.* male, *b.* female. 7. Upper part of nut-shell. 8. Cross-section of stem.

5. **Flowers.**—Out of the axils of the leaves spring the much-branched inflorescences which are at first protected by a huge spathe (fig. 106, 4). The spathe is torn open in longitudinal lines by the swelling flowers within. It remains a long time at the base of the gigantic inflorescence which is a fleshy spike crowded with unisexual flowers. Such a form of inflorescence, in which the flowers are closely arranged round a fleshy axis and the whole surrounded by a large leaf (spathe), is termed *spadix.* It is found in the Palmaceæ, Aroideæ and Pandanaceæ, which families are, therefore, sometimes grouped as Spadicifloræ. The rapid development of the spadix is only made possible by a rich flow of sap from the trunk. This explains the obtaining of palm-wine by cutting the spadix.

The flowers are unisexual, *i. e.*, both sexes grow on the same plant. They are placed on the branches of the spadix in such a way that the *male flowers greatly outnumber the female ones,* and also so that the female flowers are always near the base of the panicle and the male ones at the end. Both kinds are inconspicuous; for they need not attract any insects to carry the pollen from the stamens to the pistils. It is the wind which does this work here, and to allow for the wastage of pollen there is such an abundance of staminate flowers. The reason why the *female flowers are situated at the lower end of the panicles* is not difficult to understand; for if the heavy nuts were suspended by a long stalk, they could easily be detached by the wind.—The staminate flowers, which can be picked up in large numbers at the foot of every fruit-bearing Cocoanut tree as they drop after flowering, consist of 3 smaller and 3 greater horny, straw-coloured petals and 6 stamens. The pistillate flowers are much larger than the staminate ones. They consist of 6 petals and the pistil, but the petals are broad and increase with the growth of the egg-shaped ovary, forming a large, cup-shaped base for the ripe nut.

6. The **Nut** of this tree is wonderfully formed. The *covering* is twofold,—a fibrous mass outside, the exocarp, and a shell as hard as stone in the interior, the endocarp. Break the latter and you will get the kernel which is the *seed,* formed like a hollow ball and containing the minute germ in its pulp and a milky

substance in its cavity. The *pulp and the milk form the first nourishment of the seedling.*

But the very tender *seed-bud* is evidently too weak to push itself through the hard shell. Hence that part of the shell which is immediately over the embryo or germ is so thin that it can easily be pierced by the tender sprout. The pistil of the cocoanut is composed of 3 parts (carpels), only one of which develops and forms a germ, and we see the traces of the other two in the two other hard eyes which every cocoanut possesses. Moreover, the germ, and with it these holes in the shell, are always at that end of the nut where it is fastened to the stalk. The fibrous covering is least developed at this spot and can be easily broken through by the seedling.

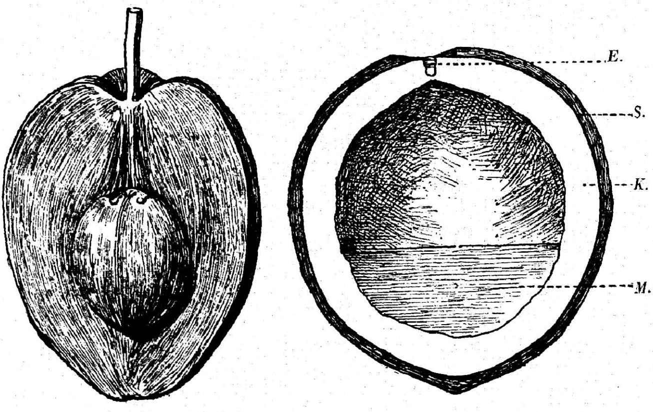


Fig. 107.—The Cocoanut with part of the fibrous covering removed. To the right the shell or endocarp (*S.*) opened, showing the kernel (*K.*), the embryo (*E.*) and the milk (*M.*).

A *fatty oil contained in the kernel* is the chief food of the young plant. Mixed with water the oil soon becomes rancid. It is partly to prevent the oil becoming thus spoiled that the nut requires a strong covering. This furnishes, of course, also a very good protection against enemies that are covetous of the sweet

fruit, and protects the seed from harm when it falls from the tree to the ground. If the nut falls by chance into the sea, the porous outer part of the covering enables it to float, and the nut can then be carried by the waves and sea-currents to a distant island where it may strike root. In this way the lonely, deserted coral reefs of the South Sea may have come into the possession of this magnificent Palm tree.

7. The Cocoanut Palm is not only one of the most beautiful, but also **one of the most useful trees** that adorn the coasts of tropical countries. The stem is useful for timber; the leaves are used for thatching houses; the soft bud of the young plants furnishes a palatable vegetable; by tapping the stalk of the inflorescence a juice is obtained, from which by fermentation palm-wine (toddy) is made, and which, if unfermented, yields a good sugar when boiled down; the middle part of the covering of the fruit yields a very useful fibre, out of which ropes are made which possess a high power of resistance to the action of water; out of the hard shell they make drinking vessels, spoons, *etc.;* the kernel has a delicious taste and forms part of the daily food of the people; an oil of good quality is obtained from the kernel; the refuse forms a food for cattle; the milk of the fruit is a delicious beverage: there is hardly any part of this tree which is not of some use to man.

8. **Enemies.**—Among the animals which destroy the tree and its fruits may be mentioned the rat, which bites a hole into the nut in order to get at the kernel, and the Goliath beetle (*Oryctes rhinoceros*), which damages the trees by cutting large holes in them through the young leaf-shoots. When the leaves open, signs of the beetle's work are shown.

Other Palms.

The family to which the Cocoanut Palm belongs, the *Palmaceæ,* is essentially a tropical one. The unbranched trunks, marked with the scars of the leaf-stalks, and their terminal crown of noble, evergreen leaves, are characteristic of the order. So are the unisexual flowers, thickly arranged in panicles or spikes within a protecting spathe. The perianth is generally 6-divided

in 2 series; stamens 3 or 6, ovary free and generally of 3 carpels. Various species of this useful order are commonly known, as they grow everywhere in the tropics.

Perhaps the commonest in Southern India is the **Palmyra Palm** (*Borassus flabelliformis.* — *Can.* Tāḷi; *Mal.* Tālam; *Tam.* Panai; *Tel.* Tāṭi; *Hin.* Tāḍ), — (Plate No. 640). This tree chiefly grows on the slopes from the cultivated valleys to the plateaus above, or on sandy plains near the coast.

The leaves are fan-shaped, their petioles serrated and spinous on the edges. The flowers are diœcious. The inflorescence of the male tree consists of several 3-forked spikes, supported by a spathe, each fork being about 1 foot long. The spikes contain hundreds of minute flowers arranged in dense spikelets, each of more than 12 flowers, covered under imbricated scales. The top flower appears from under the scale and falls off after a day, making room for the next lower one. The small flower has 3 whitish petals with brown streaks and 6 yellow stamens. The spike of the female tree is about $1^1/_2$ feet in length, each flower being wrapped up in half a dozen petals and its size being that of a cherry. The full-grown fruit is dark-brown and half the size of a cocoanut, with very tough fibres. There are 3 seeds inside, consisting of a jelly-like, hollow kernel with the germ at the end.

The spikes of both, male and female trees, are cut, and the sap which flows out of the wound is drunk as toddy, or made into jaggery. The toddy intended for jaggery is drawn in lime-coated pots, then boiled, and thus converted into jaggery.

The trunk of the tree is used for rafters. The fruit can be eaten. The leaves are used for many purposes like those of the Cocoanut Palm.

Other Palms are the majestic **Talipot** or **Fan Palm** (*Corypha umbraculifera*), which forms a huge, terminal inflorescence once in its life and dies after the seeds ripen; the **Areca Palm** (*Areca catechu*), the most slender and elegant of Indian Palms, "raising its graceful stem and feathery crown like an arrow shot down from heaven" (*Hooker*). The nut is eaten with Betel leaves.

From the stem of the **Malabar Sago Palm** (*Caryota urens*) a sago is obtained. This is simply the starch stored up in the soft

Fig. 108.—An Indian Jungle with various Palm trees.

cells (*parenchyma*) of the stem. It is also a very lofty and noble Palm, the great hanging clusters of flowers and fruits being very noticeable. The leaf-stalk makes a fair fishing rod, the fibre of the spathe a good line. A toddy is also extracted from the inflorescence in the same way as from the Cocoanut and Palmyra.

What the Cocoanut Palm is to India the **Date Palm** (*Phœnix dactylifera*) is to Arabia. Its fruits that ripen in August, come to us at Christmas time.

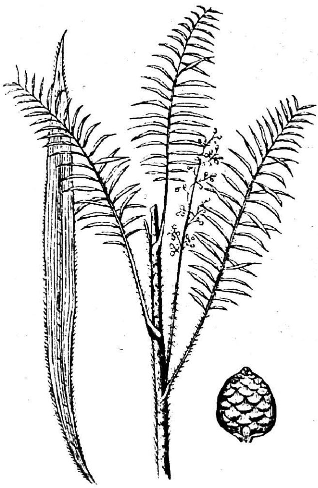


Fig. 109.—The Rattan Cane Palm (*Calamus rotang*).

The **Wild Date Palm** (*Phœnix sylvestris*) grows in many parts of India. Its leaves are used for mats, and the fleshy axis of the inflorescence yields a kind of toddy.

Another Palm, fairly common in our jungles, is the **Rattan Cane Palm** (*Calamus rotang*). The midrib of the pinnate leaf is produced in a very long slender, drooping flagellum resembling the slender lash of a whip. This is armed with recurved thorns on the under side. The flagella fasten the leafy shoot of the Rattan stem to the branches of jungle trees. When the tops of the latter are reached, the leafless part of the stem glides down, as the shoot grows, and hangs from the branches of the trees in huge slings. The stem of the Rattan can thus reach the enormous length of more than 700 feet.—The Cane is split and manufactured into numerous articles of utility. The shining outer coating of the Rattan Cane is a secretion from the plant, and consists mostly of a mineral substance, called silex, which is nearly the same as quartz. By bending the Cane it comes off in little, thin, transparent flakes.

33. The Arum Family.

(Aroideæ.)

Perennial acrid herbs. Leaves net-veined, often variegated. Flowers sessile, small, unisexual, arranged on a spadix within a spathe. Perianth usually nil. Fruit a berry.

The Kesu Plant (*Colocasia antiquorum*).

(*Can.* Kesu. *Mal.* Čĕmpu̥. *Tam.* Šīmaikiḷaṅgu.)

This plant is an inhabitant of shady and moist places. It is often cultivated for the leaf-stalks and tubers which are eaten as vegetables.

1. The peltate, arrow-head **Leaves** arise not from a stem, but from a truncated tuber, and are, therefore, called radical. They are *large and glabrous* (having no hairs). As they grow during the monsoon and in swampy soils, there is no danger of their being dried up. On the contrary, the high percentage of moisture in the air at that time tends to check the action of transpiration. To supplement this vital process and to assist in its growth the *plant is enabled to let the water pass* out *in drops from a minute pore at the tip of its leaves* (fig. 110) to which point free canals, in the substance of the leaves, converge. In this way room is made for new food-substances to be brought up by the roots. These drops can be noticed especially when the temperature is low and the air can, therefore, not hold much water vapour.

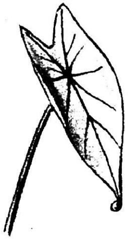


Fig. 110.—Leaf of *Colocasia* giving out a drop of water.

When it rains, the leaves do not become wet; the water runs off in silvery drops, as it would from a duck's back. This is due to a *wax-like coat* spread over the surface of the leaves. If the water wets the leaves, it wiil hinder the growth of the plant (see Lotus plant, page 2).

Cattle are careful to avoid feeding on them; for though they taste sweet at first, they leave a very acrid and disagreeable

taste afterwards, which is due to the presence of certain salts in the leaves and stalks.

2. The **Flowers** are rarely seen in the cultivated kinds of Colocasia. But they can easily be obtained from the wild variety, as well as from *Caladium,* an allied plant which is grown in gardens for its variegated leaves. In the latter the flower appears with the first leaves soon after the first rains. What is generally called the flower is, however, not a single flower but an inflorescence *spadix* consisting of a large, hood-like bract, called the *spathe,* and a fleshy spike of numerous small, unisexual flowers, so arranged that those at the bottom of the spike are pistillate and those at the top staminate, intercepted by some abortive pistils in the middle. The staminate flowers consist of a single anther, each opening by minute pores at the top, and the pistillate flowers of a single pistil, all closely packed together on the spadix.

The spadix of Colocasia appears at the end of the rainy season. It differs from that of Caladium in having the spike prolonged beyond the stamens into an acute, yellowish club which bears no flowers and serves as a means of *attracting insects* on which the plant depends for the fertilization of its ovules (fig. 111, 112).

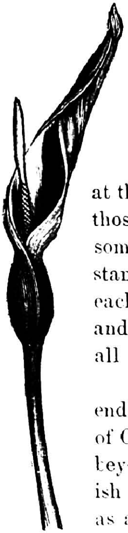


Fig. 111. Spathe and spapix of *Colocasia antiquorum* (1/3 of natural size).

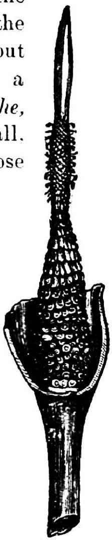


Fig. 112. Spathe removed showing spadix with pistillate and staminate flowers.

Besides this appendage and the large, yellow spathe surrounding it, insects are also enticed by

(*a*) a *strong smell* of the spadix which is disagreeable to us, but does not seem to be so to the midges that visit the flowers;

(*b*) the *nectar,* secreted by the stigmas of the pistils, and the *copious pollen* of the stamens, constituting food for them, and

(*c*) the *high temperature* in the globular enlargement of the spathe at its lower part, causing them to seek refuge there.

3. After flowering the spathe fades and nothing remains of the whole spadix, except the lower part where the pistils ripen into a cluster of **Berries** to be eaten and dispersed by birds.

4. After this the whole plant withers and perishes, excepting the **Tubers**, in which plenty of food is stored up for the next season. When the rains begin again, these plants are among the first to cover the ground with their fresh green.—It is also through these tubers that the plant is propagated. Like the Potato, it throws out long underground shoots, portions of them being filled with starch and swelled up to form fresh tubers which eventually grow into separate plants.

5. Another well-known species of this order is *Alocasia macrorhiza* (*Can.* Marasaṇige), the gigantic tubers of which are eaten after the acrid and poisonous juice, characteristic of the family, is driven off by the process of cooking.

Allied Families.

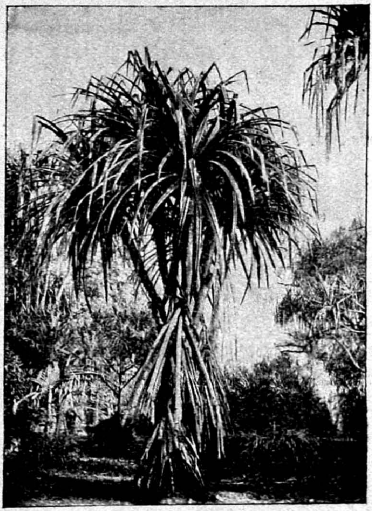


Fig. 113.—*Pandanus australiana*.

The **Screw-Pine** (*Pandanus odoratissimus* — *Can.* Kēdage; *Mal.* Kētaki; *San.* Kētakī) belongs to the *Pandanaceæ*. It is often planted for fences on account of its sword-shaped, sharply-toothed, spinous leaves which are also used for matting. Like the Mangrove tree, it forms numerous adventitious roots from the lower part of its trunk which look like artificial props. The male flowers, growing on a long, pendulous spadix, enclosed within large, leaf-like, yellow bracts,

yield a most delightful fragrance. The fruit borne on separate trees (diœcious!) is, similar to the pine-apple, a mass of united, fibrous drupes.

The Duckweed Family (*Lemnaceæ*) is another allied family. The **Common Duckweed** (*Lemna globosa—Can.* Nirāṭa) is a minute, scale-like, green water-plant kept horizontally on the surface of stagnant water by one long, vertical root hanging in the water. The plant flowers rarely and is chiefly propagated by side-shoots issuing from the mother plant. They multiply at such a rate that whole ponds become covered with them, as with a green carpet, in a very short time.

Somewhat larger than the Common Duckweed is *Pistia stratiotes*, also a floating herb, but with a rosette of wedge-shaped leaves and a tuft of numerous fibrous roots hanging in the water.

34. The Lily Family.

(Liliaceæ.)

Usually bulbous herbs with parallel-veined leaves. Flowers radial. Perianth regular, 6-leaved in two whorls. Stamens 6 in 2 whorls. Ovary superior, formed of 3-carpels. Fruit a 3-celled capsule.

The Gloriosa (*Gloriosa superba*).

(*Can.* Karaḍi-kaṇṇu, Śivaśakti-baḷḷi. *Mal.* Mēttōnni *Tam.* Kāndaḷ. *San.* Amrata, Haripriya.)

1. The Gloriosa is one of our most beautiful ornamental plants. During the rains you find it shooting in the lanes, bordered thickly by huge Euphorbia and Aloe, or in Bamboo-thickets. The grace of its form amidst the stout and ugly plants with their fierce thorns and spikes, and the gaiety and warmth of its flowers

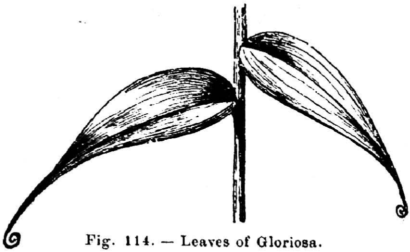


Fig. 114. — Leaves of Gloriosa.

amidst the sullen and cold grey of the surroundings have, no doubt, given cause to the superb name the flower bears.

2. It is a fragile, weak **Climber** that sprouts up from biennial tubers, hidden under the ground. The round, green stem is very slender and long, so that it is obliged to seek the support of other plants or things. For this purpose it uses its leaves which are tapering tendril-wise asking for something to curl round it and climb. And thus the plant raises its top to the free air and full sunlight "unfurling its fire-flowers like banners of triumph".

3. The **Flowers** are exceptionally beautiful. They are placed in large racemes and hence become visible from a great distance. The floral cover is a perianth of 6 leaves arranged in 2 series of three each, as can be easily seen in the green bud. The petals in the drooping bud are folded over the inner essential organs of the flower. When the blossom opens, they curl back, the 6 stamens stand out at right angles from the floral axis, and the long, slender style bends away from the hanging ovary at an acute angle and lies in the same plane as the stamens.

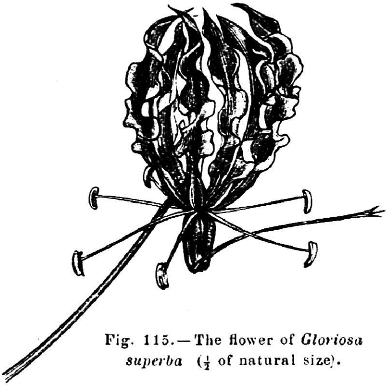


Fig. 115.—The flower of *Gloriosa superba* (½ of natural size).

The flower has no scent, but by the showy colours of its petals it is able to attract insects. The petals are bright yellow with scarlet tips at first; as they grow older and older, they become darker and darker crimson and bend more and more back. Visiting insects find honey in a hollow longitudinal furrow at the base of each petal. They suck it by thrusting their long tongue into the nectary while hovering in front of the flower and beating the stamens with their wings. When they visit another flower they thus carry the pollen of the first flower over to the

style of the second. We now understand why the style bends like a knee and places itself in one plane with the stamens.

4. The **Stamens** and the **Pistil** are unusually large in this flower and serve us as good specimens for the study of these organs.

Examine some stamens in one of the green buds. We find that they consist each of 2 parts, a filament and a head. The head, called the anther, is grooved both along the face and the back. These grooves divide the anther into 2 lobes, right and left. If we cut the unripe anther transversely, we shall see two bags filled with a fine yellow powder, the pollen. When ripe, the 2 anther-bags split up along their edges and allow the pollen to be removed by insects, as we have seen above.

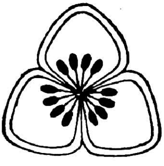


Fig. 116.—Diagram of ovary of Gloriosa.

The essential part of the pistil is a knob-like vessel, called ovary, on the top of the flower-stalk. In Gloriosa the ovary consists of 3 leaves or carpels, which fold in and unite at their edges in the axis, so that there are 3 hollow spaces to hold the ovules, which can be seen when the ovary is cut transversely. The ovules are attached to the seams of the carpels, and appear in the transverse section (fig. 116) as axillary growths. The tips of the three carpels unite together and taper into a slender style which again betrays its threefold nature by a three-parted stigma.

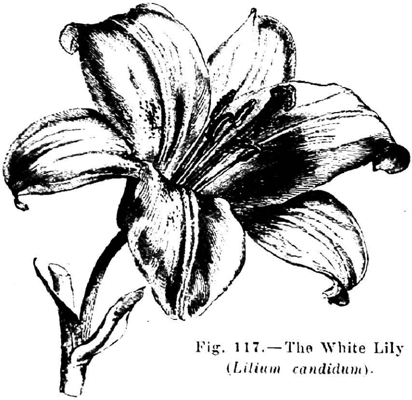


Fig. 117.—The White Lily (*Lilium candidum*).

Other Lilies.

The family of the Lilies to which the Gloriosa belongs, is much celebrated in poetry. The **White Lily** (*Lilium candidum*, fig. 117), growing in temperate climates, is the emblem of purity.

Other plants belonging to this family are the **Onion** (*Allium cepa*—*Can.* Nīruḷḷi; *Mal.* Īruḷḷi; *Tam.* Īruḷḷi; *Tel.* Nīruḷḷi; *Hin.* Pyāj), the **Garlic** (*Allium sativum* — *Can.* Beḷḷuḷḷi; *Mal., Tam., Tel.* Veḷḷuḷḷi; *Hin.* Lasun), the **Leek** (*Allium ampeloperasum*), the **Dragon Tree,** *Dracæna ferrea* (fig. 118), with copper-coloured leaves, crowded together at the top of the stem, and panicles of small purplish flowers, and the **Wild Asparagus** (*Asparagus sarmentosus* — *Can.* Halavumakkaḷatāyi; *Mal.* Čadāvēḷikiḷañu; *Tam.* Čāttiravēri; *Tel.* Čallagaḍḍalu).

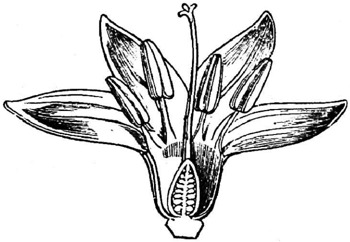


Fig. 118.—Flower of *Dracæna*, in longitudinal section. (2 petals of the perianth are removed.)

The latter has no bulb like most of the other Lily plants, but a bundle of many long, perennial tubers, from which numerous sprouts shoot up. The roots are very long and are thus able to carry water and food from a great distance. The delicate climbing stem has thorns turned downwards (necessary for climbing, compare Rose, page 42). The leaves are reduced to filiform, recurved needles. The white flowers are small but numerous, and form racemes from the axils of the thorns. The fruit is a red berry.—The tubers are used medicinally.

The Bulb of the Onion.—The bulbs of the Onion deserve our special notice. Generally those parts of a plant which are under the ground, are called roots. Roots proper are, indeed, under the ground, or, at any rate, grow downwards, shunning the light and seeking the ground, when they issue from the upper part of a plant, *e.g.,* the aërial roots of the Banyan tree or those of the Mangrove; but growths like the bulb of the Onion, the tubers of the Potato plant, or the root-stock of Ginger, are not roots. They are a sort of stem, growing under the ground for certain reasons. To understand the nature of a bulb, we take an Onion and cut it through. We see a compact mass at the lower end (near the fibrous roots), and a number of concentric, overlapping

leaves or scales above it. Within the scaly leaves we can often clearly distinguish leaf- and flower-buds.

The bulb is of great *importance* for the plant. During the greater part of the year no rain moistens the ground which becomes hard and dry, and all those plants, which are not specially furnished with protective arrangements against drought, die. They are called *annuals,* as they do not live for more than a year (*Latin: annus* = year). Other herbs can live not only through the whole year but also for an indefinite number of years and are, therefore, termed *perennials.* It is generally the underground stem which enables them to do so. Their upper parts wither likewise under the scorching rays of the sun, but as soon as the first showers of rain fall, they awake, as it were, from their sleep, and in some cases send up flowers even before their leaves appear.

The outer scales of the bulb are dry and leathery and form a *protective coat* over the inner juicy leaves, preventing loss of moisture by evaporation. They also sometimes contain a poisonous substance, saving them from the attacks of animals.

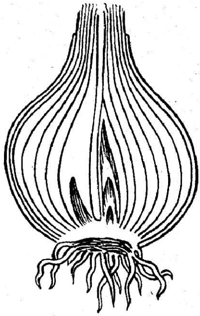


Fig. 119.—Longitudinal section of the bulb of an Onion.

Bulbs, like the Potato tubers (page 84) or the root-stocks of Ginger and other plants, are a *food store* for the coming season. At the base of the bulb there is a tuft of fibrous roots, which gather salts and water from the soil. But, as we have already learnt, this food does not form the chief material of which plants build up their body. They require another kind of food in addition to the water and the salts of the soil, namely the carbonic acid in the air, and this they obtain by their leaves. Starch is formed out of these two kinds of food which is converted into sugar and other substances, distributed from cell to cell all over the plant, and used up wherever growth is taking place, or stored up as a reserve of material for future

use. Such a store of food is the bulb. When in the beginning of the rainy season the plant awakes, it sends forth, from the solid white base of its bulb (which is the shortened stem of the plant), not only roots, but also a rapidly growing shoot with great and numerous leaves, such as could never be produced at this rate by the plant without a rich reserve of food.

The bulb becomes soft and shrinks as the plant grows and as its contents are being used up. But after a short time, new young bulbs are produced from the stem in the axils of the scaly leaves. As the plant grows and the outer scales of the mother bulb wither one by one, these young bulbs move to the periphery and grow larger and larger, the mother bulb storing more and more food in them for the future growth of the daughter bulbs. At last, the latter come apart and grow as independent plants. In this way the Onion is able to *multiply* as well as from seed.

35. The Amaryllis Family.

(Amaryllidaceæ).

Herbs very much like the Lilies. Ovary inferior.

The Asiatic Crinum (*Crinum asiaticum*).

(*Can.* Vishamuṅguli. *Mal.* Veḷuttapoḷatāḷi. *Tam.* Tuḍaivāči. *Tel.* Kesaričeṭṭu. *San.* Vishamandala.)

This is a perennial herb with large bulbs, pretty common everywhere, and very conspicuous by its large, glossy, radical leaves (compare Ginger), from among which a scape, 2 feet long, arises bearing an umbel of numerous white flowers.

The perianth consists of two whorls of 3 petals each, which are all combined into a long tube spreading at the upper end into 6 equal segments. The outer whorl of this perianth ought to be called the calyx, and the inner one the corolla; yet from their being both coloured, and otherwise very much alike, the whole is called the perianth (see also Gloriosa). The 6 stamens

adhere at their bases to the petals. The ovary is 3-celled as in the Lilies, but inferior. The fruit is a berry with one or two seeds.

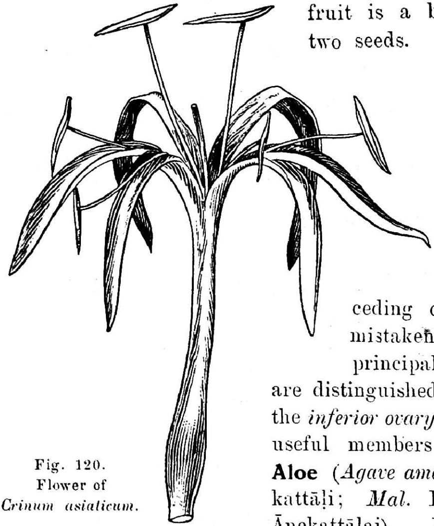


Fig. 120.
Flower of
Crinum asiaticum.

The bulb and the leaves are poisonous, and are used as emetics.

Other Amaryllids.

These plants bear a close resemblance to the preceding order and are often mistaken for true Lilies. The principal mark by which they are distinguished from the Lilies is the *inferior ovary*. One of their most useful members is the **American Aloe** (*Agave americana — Can.* Ānekattāḷi; *Mal.* Erōppakaita; *Tam.* Ānekattāḷai). It is a well-known shrub used for fences on account of its thorny leaves. Its growth is very slow. It requires about 10 to 15 years until it is fully grown. But then a high scape with hundreds of pale, yellow flowers grows suddenly out of the leaf-rosette, to the height of 10—25 feet. After the seeds are ripe, the whole plant dies off. Ere this event takes place, however, numerous shoots issue, like children, all round the root-stock. The Agave was imported into India from America where it inhabits the dry deserts of the tropical and subtropical zone. By its succulent leaves which are covered by a leathery epidermis it is well suited for such climates (compare Cactus, page 53).—A very strong tough fibre is obtained from the leaves.

Some of the Amaryllids have very handsome flowers and are prized in gardens, *e.g.*, the **Amaryllis** with its large, red flower-bells; the **Eucharis Lily** (*Eucharis grandiflora*) with fragrant,

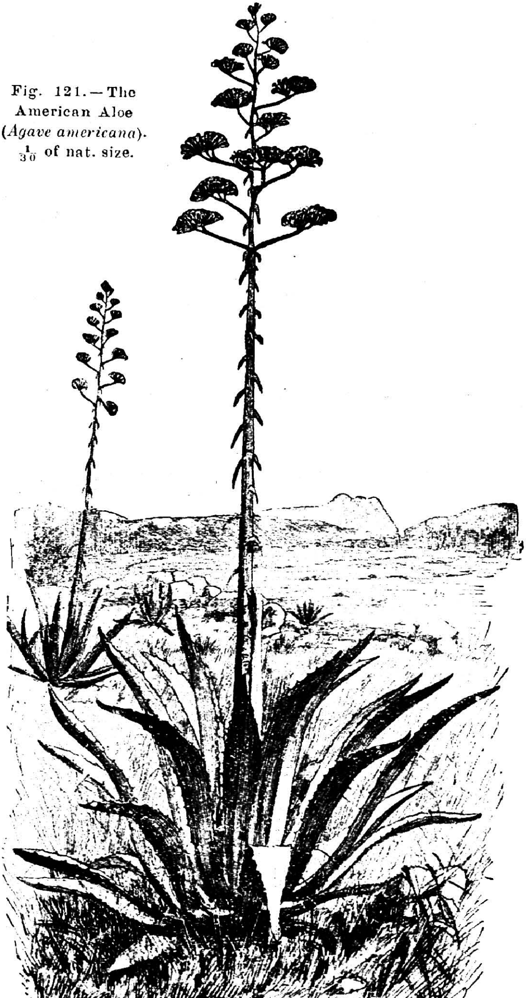


Fig. 121.—The American Aloe (*Agave americana*). $\frac{1}{30}$ of nat. size.

white flowers, embellished by a membrane within the perianth stretching from filament to filament and forming a cup; the white **Pancratium**; and the pretty, rose **Zephyr Flower** or American Crocus (*Zephyranthes rosea*).

A family closely related to the Amaryllids is that of the *Bromeliaceæ* to which the **Pine Apple** (*Bromelia ananas*) belongs.

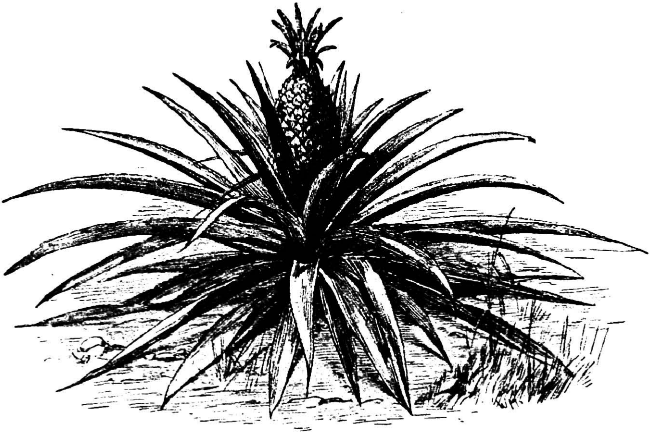


Fig. 122.—The Pine Apple (*Bromelia ananas*). $\frac{1}{12}$ of natural size.

The sweet and tasteful fruit consists of numerous flowers and bracts, all grown together in a mass. The crown of leaves, which looks so out of place, growing apparently out of the fruit, belongs really to the flowerless top of the spike and is capable of developing into a fresh plant.—The fibre of the leaves is used and the plant is often grown for fences.

Another allied family is the **Yam Family** (*Dioscoreaceæ*). They have stems twining from left to right, and cordate or digitate, net-veined leaves, in whose axils often brown tubers are borne. The tubers of some species (*Dioscorea sativa*—*Can.* Kuṇtageṇasu; *D. alata* — *Can.* Tūnageṇasu; and others) are edible.

36. The Orchid Family.

(Orchidaceæ.)

Perennial herbs with zygomorphic conspicuous flowers. Perianth with 6 petals arranged in two whorls; the 3 sepals of the outer whorl more or less alike, in the inner whorl the 2 lateral petals alike and narrow, the lower (lip) large, lobed, and spurred. Stamens and style united into a *column* opposite to the lip, the pollen in two masses. Ovary inferior, of 3 carpels, twisted. Fruit a capsule with many seeds. — Either terrestrial with tuberous roots and annual, simple stems, or epiphytes with perennial stems and branches, thickened and shortened into a bulb-like mass (*pseudo-bulbs*).

The Round-leaved Habenaria (*Habenaria rotundifolia*).

(*Can.* Nelatāvare, Oreletāvare.)

1. When the rains begin to moisten the ground after the long drought from October to May in Western India, the terrestrial Orchids, which are to be found in hills and dales, also awaken and send up their shoots to the light and air. For, their **Tubers** enable them to form leaves and stems at once from the reserve food contained in them. This food is mainly starch and is so rich that, in some kinds, it can be used for the preparation of food for man, the "salep".

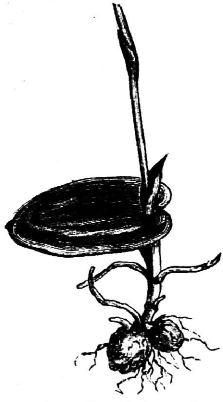


Fig. 123.—Tubers of *Habenaria rotundifolia* at the time of fruiting (½ of natural size).

If the plant is dug out early in the season, a young bud can be seen in the axil of one of the dry scales that surround the shoot. This bud gradually swells and becomes a tuber, like the old one, so that, if we examine the plant at about the time of flowering, in July, its size is equal to that of the old one, the mother-tuber, which then already shows signs of shrivelling. If

the plant is examined once more when the fruit is ripe, the mother-tuber will be found brown and withered, whereas the daughter-tuber will be firm, light-coloured, stuffed out, and provided with a bud at its upper end. These phenomena are the same as those which we have noticed in the Potato tuber (page 84) and the bulb (page 146): The reserve food in the tuber is used for the building up of the leaves, flowers, and fruit of the plant, during which process the plant stores fresh food in a new tuber for use in the following year, and the old tuber being exhausted falls off and decays.

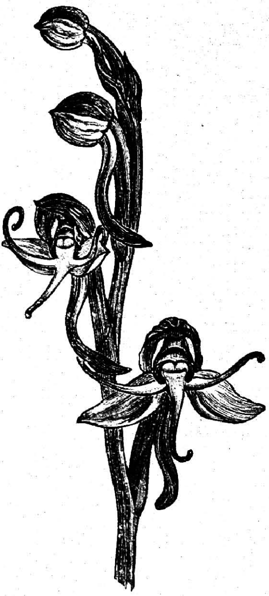


Fig. 124.—Flower spike of *Habenaria rotundifolia* (2 times magnified).

2. The sprout of *Habenaria rotundifolia* forms one or two round **Leaves** (fig. 123), pressed close to the ground. Their resemblance to the leaves of the Lotus-plant has given origin to the vernacular name *Nelatāvare,* which means Ground-lotus.—They are quite *smooth.* Being surrounded by the moist air of the monsoon, and growing in swampy soil which affords an ample supply of water, the plant can dispense with the protective coat of hairs which we frequently find on the stems and leaves of plants growing on dry soil and during the dry seasons. The leaves are *dark-green,* which is likewise referable to the habitat of the plant. Dark-coloured things, we know, absorb more heat than light-coloured ones. The higher the temperature of the leaves of a plant rises, the more abundant is the evaporation and hence the growth (see II. Part, Transpiration). The damp surroundings which naturally check the evaporation, are thus compensated for by the dark colour of the leaves.

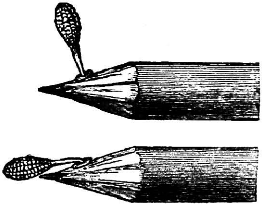
The thick, fibrous roots which spring from the stem immediately over the tubers, are few and small; they are sufficient for the supply of water from the soil which is constantly humid during the time of its growth.

3. A slender, leafless stem, called scape, about six inches high, rises from the radical leaves and lifts the few **Flowers** over the tips of the grass around it. They thus become visible to passing insects which have to fertilize them.

Each flower is attached to what seems to be a short flower-stalk rising from the scape; but it is really the ovary, which can be proved by cutting it through and thus laying the ovules inside bare.

The perianth is composed of two sets of 3 leaves each. The middle petal of the outer set and the 2 upper or lateral petals of the inner set are bent together and form a hood to protect the inner organs. The 2 other outer petals are expanded, and the middle petal of the inner set, generally called the lip, is divided into 3 narrow lobes and drawn out into a long, slender spur. Close to the entrance to the spur we find the stigma of the pistil with a sticky surface, and above it, the stamen which contains two pollen-masses in a pouch each, which look like 2 small clubs and end in a gummy disk below, covered under a small, knob-like projection.

This very peculiar structure of the Orchid-flower is fully understood only when we study the mode of its *pollination by bees*.



1.

2.

Fig. 125.—Pollen-masses at the end of a pencil: 1. immediately on the withdrawal of it, 2. one or two minutes afterwards.

The flowers are small, indeed, but their white colour makes them visible as they are raised by their stems above their surroundings. A bee seeing them alights on the expanded under-lip which affords a convenient landing place. It then stretches its proboscis into the spur in search of nectar. Just at the entrance to the spur are the projections which contain the sticky disks of the pollen-

clubs under small lids. As the insect touches these with its head, they break up, and at once the sticky disks settle on the forehead of the insect. On leaving the flower the pollen-masses are drawn out of their pouches and the bee flies away with them. If this process is imitated by gently inserting a pointed

Fig. 126.—An Orchid (*Cattleya sp.*) growing on the bark of a tree, with pseudo-bulbs (½ of natural size).

pencil into the spur and withdrawing it, one can see that the clubs which are erect in the beginning bend forwards after a minute or two (fig. 125). The same happens, of course, when the pollen-clubs are on the head of the bee. When it thus visits another flower, the pollen-masses must touch the stigma of it, and this will detach some or all of the pollen from the bee's head. The flower is thus fertilized.

4. The **Fruits** are capsules containing numerous powdery seeds which are shaken out and dispersed by the wind when the capsules split into their 6 valves.

Other Orchids.

The Orchid Family comprises more than 5000 species. Many of them have very showy flowers. They occur largely in the hill tracts of India, and as they do not get sufficient light on the ground in a forest, they frequently settle on the trunks and branches of trees. They are, however, not parasitic, preying on the juice of the trees, like the Loranthus, but simply throw out cord-like aërial roots by which they attach themselves to the bark. They feed on the dust blown by the wind into the fissures of the bark, and on the rain and dew falling on them. Such a habitat must be unfavourable, indeed, during the rainless season; but in many genera of the Orchids this is compensated for by the lower joints of the stems or leaves becoming much thickened and fleshy (pseudo-bulbs), so as to resemble bulbs, where they store up each drop of water they can get. (See also page 125!)

A very common type of these epiphytic herbs is *Vanda Roxburghii* (*Can.* Marabāḷe), frequent on Mango and Banyan trees. It has axillary racemes of sweet-scented, chequered, yellowish and purple flowers and succulent, recurved leaves in which water is stored up.

Vanilla planifolia is cultivated for its fruit, which is taken when unripe and yields the well-known aromatic essence "Vanilla".

The pretty snow-drop like Orchid commonly found on the trees of the Ghauts is *Cœlogyne flaccida*.

37. The Ginger and Arrowroot Family.

(Zingiberaceæ.)

Perennial herbs with radicle leaves, which are pinnately nerved from the mid-rib. Flowers zygomorphic. Sepals 3, free or united. Petals 3, tubular. Stamen one with 5 petaloid staminodes. Ovary inferior, 3-celled. Fruit a capsule.

The Ginger Plant (*Zingiber officinale*).

(*Can.* Çuṇṭhi. *Mal.* Iñci. *Tam.* Iñji. *Tel.* Çuṇṭhi. *Hin.* Sōṇṭ.)

1. This is a herb with a creeping **Root-stock** (*rhizome*) containing a great deal of starch and an ethereal oil which gives the tubers an agreeable aroma and a warm, bitterish taste. It is cultivated, and the root-stocks are used as spices and in medicine.

Ginger grows well in the shade and may be advantageously cultivated under fruit trees, such as the Mango or the Jack, the trees themselves being benefited, if the land underneath is kept cultivated.

If we examine the root-stock of a Ginger plant, as it is sold in the bazaar, we shall see that it contains buds or "eyes" at its ends and some scars in its middle portion (fig. 127). If it is planted, the buds will produce leaves and, perhaps, flowers; whilst new buds will be formed at the further end of the root-stock. This *underground stem* thus creeps along under the soil producing fresh buds every year, slowly moving away from the spot where the former plant grew and thus always seeking fresh, unused soil. The old portion marked with the scars of withered plants decays, and as the side-buds similarly creep along in opposite directions, independent plants are produced eventually. The branching of the root-stock is, therefore, *a means of propagation,* and this is by no means an unimportant one as the Ginger plant rarely flowers to produce seed.

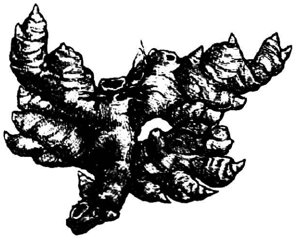


Fig. 127.—Rhizome of Ginger (*Zingiber officinale*). ½ of natural size.

2. **Leaves.**—The Ginger plant grows during the monsoon and so does not require a protective coat of hairs on its stem and leaves (*cf.* Habenaria, page 152), or other means of checking the process of evaporation, such as a limited surface of the leaf-blades. It can, therefore, develop large and long leaves. The leaves, like all the other parts of the plant, contain the volatile

oil which we have noticed in the root-stock and which gives them a fine aroma when bruised.

3. The **Flowers** appear not on the leafy stem, but are produced on separate scapes that rise from the root-stock, a little removed from the leafy stem. They form a spike at the top of the scape, being supported and protected by imbricated, concave bracts.

The perianth of the flower is tubular and has a double border of 3 lobes each. Within the perianth there are 6 "leaves" in two sets, belonging to the staminal series of which, however, only one bears an anther. Of the rest 2 are reduced to minute teeth, nestling around the base of the style, whereas one is enlarged to a violet, petal-like lip and two are found as short teeth or lobes at each side of the lip. The anther-bearing stamen is drawn out into a purple sheath clasping the upper part of the style, whose funnel-shaped stigma overtops all parts of the flower. The arrangement of these inner organs clearly shows that self-pollination is impossible.

Other Plants of the Ginger and Arrowroot Family:

Many plants of this and the allied family *Marantaceæ* are useful as food-stuffs, spices, and dyes. Arrowroot flour is made from the root-stocks of *Maranta arundinacea* and of *Curcuma angustifolia* (*Can.* Kūve; *Tam.* Kūkai). The seeds of **Cardamom** (*Elettaria Cardamomum* — *Can.* Ēlakki; *Mal.* Ēlam; *Hind.* Ēlāči) are used as spices. The root-stock of **Turmeric** (*Curcuma longa*— *Can.* Arisina; *Mal.* Maññaḷ; *Tam.* Maňčal) yields a common dye.

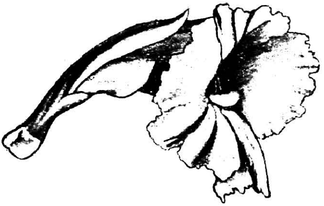


Fig. 128. — Flower of *Costus speciosus*.

Garden plants are **Costus,** *Costus speciosus* (*Can.* Pushkaramūla; *Mal.* Čannakkūva: *Tam.* Kōshṭam), a most elegant looking plant, remarkable for its spirally ascending stem and the 2 white glossy petal-like stamens, beside which the 3 small red sepals and the 3 white petals proper sink into insignificance,

and the **Indian Shot** (*Canna indica*—*Can.* Kēḷahū; *Mal.* Kāṭuvāra; *Tam.* Pūvāḷai).

38. The Banana Family.

(Musaceæ.)

Herbs very much like the Zingiberaceæ, differing chiefly in the arrangement of the petals and stamens.

The Banana or **Plantain** (*Musa paradisiaca*).

(Plate No. 636.)

(*Can.* Bāḷe. *Mal.* Vāḻa. *Tam.* Vāḻai. *Tel.* Araṭi. *Hin.* Kēli *San.* Kadali.)

1. **Stem and Leaves.**—The stem, formed from the sheaths of the leaves, attains a height of from 15 to 20 feet and is very succulent. In its centre is a white, solid substance, the stem proper, forming a cylinder throughout its length, and bearing the flowers and fruit at its end. In young plants this stem is represented by a tuberous mass from which the fibrous roots grow downwards and the leaves upwards. (*cf.* bulb, page 145).

The leaves are *very large,* 6 to 8 feet long and 2 feet broad, and would, therefore, offer much resistance to the wind, the pressure of which the weak stem could hardly withstand. To prevent the plant being thus overturned, nature corrects herself in a very simple manner: The leaves have a strong, fleshy mid-rib, from which the veins run to the margin at right angles, and they *split readily when swayed by the wind;* the leaf now acts like a pinnate leaf, the various parts letting the wind pass between them, and thus lessening the resistance (*cf.* Cocoanut tree, page 132). The mid-rib and the stem-clasping sheath contain numerous large cavities, the result of the very quick growth of the plant, there being hardly time enough to provide the food-stuff required to form so much tissue. The cavities of the sheaths are filled with water when there is plenty, and out of this reservoir of water the plant derives its supply when the rains cease.

2. **Flowers.**—The continuation of the central cylinder beyond the stem forms the flower-stalk. It is, therefore, evident

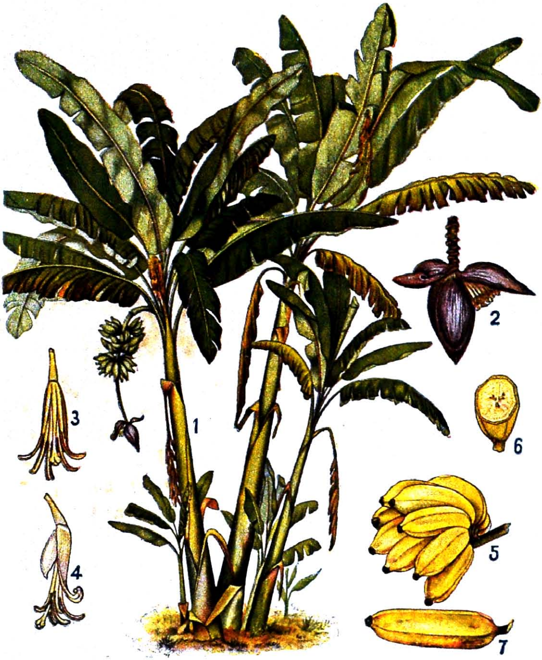


Fig. 129.—Banana or Plantain *(Musa paradisiaca)*.

2. Head of spike. 3. Single flower (front petal removed). 4. The same, petal not removed. 5. 6. 7. Fruit.

that a tree can bear but once, after which it is cut down, and a new shoot springs up from the root, by which means the Plantain is chiefly propagated. The closely packed, conical *inflorescence* (fig. 129) inclines downward by its own weight in a graceful curve. The flowers are arranged in whorls or clusters. Each whorl of flowers is protected under an ovate, concave, leathery spathe, crimson on the inside and with a pale bloom on the outside. Eight or more of these, nearest the base of the huge, drooping spike, embrace a double row of 10 to 16 flowers which are fertile. With the maturity of each successive row of flowers, the spathe reclines and falls off, and the fruit appears. The rest of the whorls—and they are very numerous—expand in succession for 2 or 3 months and contain similar double rows of flowers which, however, do not bear fruit but fall with their spathes.

The perianth consists originally of 6 petals arranged in 2 whorls (compare Lilies, Amaryllids, Orchids and Zingiberaceæ). The 3 outer sepals and two petals of the inner whorl are united into a tube with a slit throughout its length, in which the third petal of the inner whorl is seated. The 5 lobes of the floral tube betray its composition. The stamens are ordinarily 5 in number, the sixth being abortive. Plenty of nectar is secreted from the base of the flower, and bees are often seen swarming about the spike to fetch the nectar and, in return, to fertilize the flowers. The stamens of the flowers in the eight or more first whorls of the spike are sterile, whereas their large styles, crowned with a clammy stigma, are fertile. Inversely, the pistil is sterile and the stamens are fertile in the flowers at the tip of the spike, which, therefore, are dropped after flowering.

3. The well-known **Fruit** is an oblong berry, tapering at each end and of a fleshy consistency (fig. 129, 6). The numerous seeds in it are usually not developed. The plant is, therefore, not propagated by seeds.

With the production of fruit the growth of the tree ceases. The life-time is from 9 months to 3 years, and under good conditions ordinarily about a year. During this short time the Plantain tree develops into that stately and magnificent tree, a phenomenon which is unique even in the tropics. The plant is,

therefore, highly esteemed by the Hindus as the emblem of plenty and fertility, and is, as such, in constant requisition at their marriages and other festivals for ornamenting the entrance of houses and temples.

Besides the fruit, which is eaten in many ways and also dried and made into flour, the fibres of the sheaths and of the leaf-stalks are used. The leaves are used by Brahmans instead of plates.

4. In the life-story of this plant, which has been cultivated for ages, we see a great **Anomaly**: *The seeds of the plant are not properly developed.* This is the result of man's interference with the natural growth of the plant, as can be observed in the wild species, *viz., M. sapientum,* or in *Musa superba,* a plant often grown in gardens for its gigantic, ornamental leaves. The fruit of this kind bears numerous black seeds embedded in very little pulp, which produce healthy plants. By constantly preferring and selecting sorts with richer pulp and paying no attention to the seeds which were useless to man and not necessary for reproduction, a variety was eventually obtained which produced nothing but pulp in the fruit. (Compare the inferiority of the seeds of the Potato plant, page 86.)

39. The Grass Family.

(Gramineæ.)

Herbs (except the Bamboo), with a jointed, hollow, leafy stem, called *culm* or *haulm*. Leaves entire, straight-veined, sheathed. Flowers glumaceous, *i. e.*, consisting of dry and scaly *glumes*. Stamens generally 3 (6 in Rice). Ovary crowned with 2 feathery styles. Seeds mealy and often nutritious.

The Rice Plant (*Oriyza sativa*).

(Plate No. 626.)

(*Can.* Bhatta. *Mal.* Ari. *San.* Vrīhi.)

1. **Importance.**—Rice is the principal food of about $\frac{1}{3}$ of the population of the world, and is, therefore, the most useful and most important of all cereals. It is found wild in some parts of India, but has from time immemorial been cultivated throughout

the warmer regions of the world. What bread is to the people of the temperate zone, boiled rice is to those of warmer countries.

2. **The Grain and its Germination.**—The rice grain is a small, greyish-yellow thing. The seed proper is enclosed in 2 hairy husks or glumes, the larger of which is five-nerved and sometimes terminates in a bristle (awn). If the husks are carefully removed, the whitish or pinkish seed appears with the small germ at its lower end.

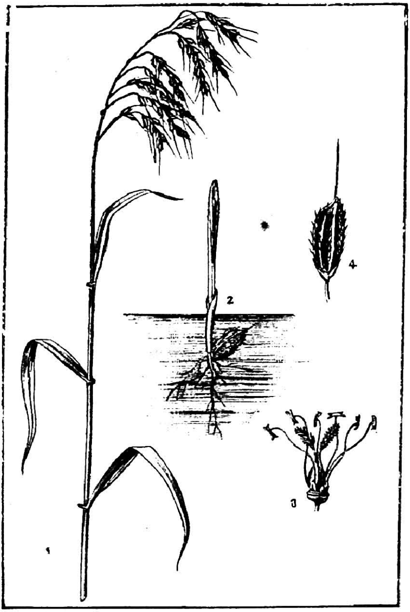


Fig. 130.—The Rice Plant (*Oryza sativa*).
1. Flowering plant. 2. Seedling. 3. Flower. 4. Grain.

In the Pea (page 28) we have found the germ or embryo lying between two thick seed-leaves or cotyledons. The structure of the grain of Rice is quite different. Here we have a very small germ at one end of the seed, the remaining part of the grain being filled up with a mealy substance, called *endosperm*. The germ has not a pair of seed-lobes like the Pea, one opposite the other, but a series of very small, rudimentary leaves of which the outer, sheathing the inner ones, is regarded as a seed-leaf or cotyledon (fig. 138). Hence Rice is grouped under the *monocotyledons*. The inner leaves belong to the plumule, and the lower part is the radicle.

If the seed is sown, it will be seen, as in the Pea, that the rootlet of the embryo makes its appearance first. But, whereas the root of the Pea elongates forming a tap-root from which side-roots are thrown off, the radicle of the young Paddy plant sends forth *numerous similar roots from small sheaths* at the base of the seed forming a bundle of fibrous roots. Meanwhile the bud of the plantlet grows upwards piercing the earth or mud lying over it, with its spear-like point.

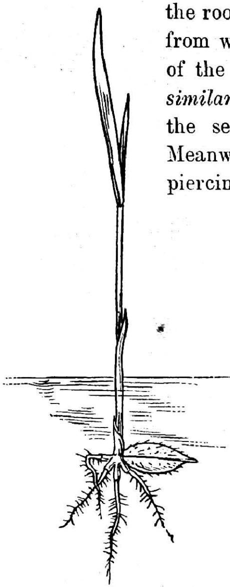


Fig. 131.—Young Paddy Plant.

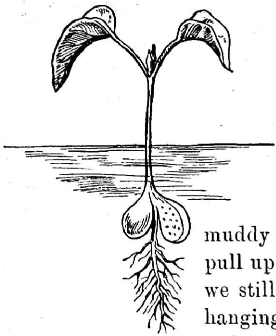


Fig. 132. Young Pea Plant.

Rice is sown in wet land. After a few days their thin blades peep out of the muddy water. If we pull up one of them, we still see the seed hanging on the lower end of the young plant. But the husks are now empty. The little Paddy plant has used up the contents for forming its tiny roots and blades. From this we learn that the mealy substance which filled the seed, must be of the same importance to the young Rice plant as the thick seed-lobes of the Pea seed are to that plant. It is *a deposit of nourishing matter for the support of the young plant in its first stages of growth.*

It contains about 80% of starch and 7% of albuminoids (substances like the white of an egg). As these two stuffs constitute the essential parts of human food, we can understand why rice is so valuable to man.

3. **Stem.**—After some time the little plants, sown closely in small seed-beds, are taken up and planted out again. If this

were not done the plants would choke one another. This process also forces the plant to form more numerous and stronger roots which are helpful for a rich crop. Roots grow freely out of the lower nodes of the stem.

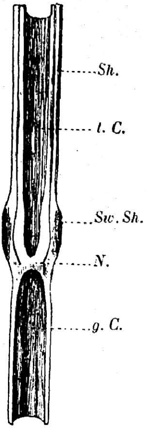


Fig. 133.—Longitudinal section of a Grass-culm. *g. C.* Full-grown and *t. C.* tender part of an internode. *N.* Node. *Sh.* Sheath of a leaf. *Sw. Sh.* Swelling of the leaf-sheath above the node.

The plants soon produce stems, called *haulms or culms,* usually 3 to 4 feet long. Although they are very thin, they are strong enough to bear the weight of their leaves and that of the grain in the panicles. They are *elastic* and, when blown to and fro by the wind, suffer no injury. As in the stems of the Labiatæ (page 99), it is the outer part of the stem that suffers the greatest pressure when bent. Those plants, therefore, have the four edges of their stems strengthened by strong fibres. In the grass culm *a round tube* is formed by such strong fibres. The tissue in the middle disappears, as it has to bear no pressure when bent: *the culm is hollow.* Only the *nodes are solid* and divide the culm into various parts, called internodes. This serves to strengthen it.

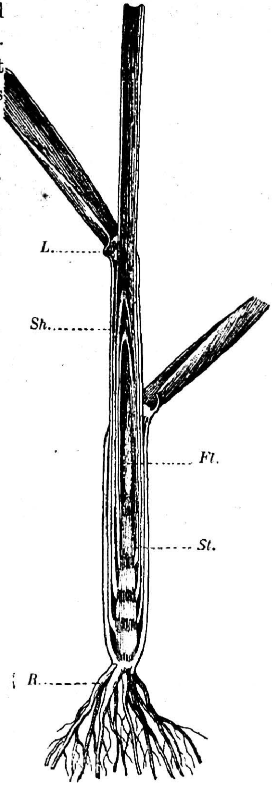


Fig. 134.—Longitudinal section of a young Grass-culm. The stem (*St.*) with its leaves and inflorescence (*Fl.*) grows under the protection of the sheaths (*Sh.*) of the older leaves. *L.* Ligule. (Natural size.)

That part which is to suffer the greatest tension, namely *the base* of the culm, *has its nodes nearest together* in order to make it stronger at that particular part.—Paddy has its roots under water; and these must be supplied with air (see Lotus, p. 3), which is done by air-chambers and canals running through the tissue of the stem and of the leaf-sheaths.

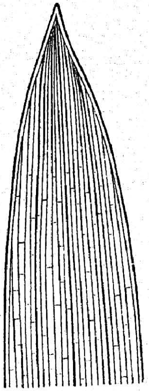


Fig. 135.—The tip of a Grass blade.

4. **Leaf.**—Each leaf consists of two quite different parts, the *sheath* and the *blade*. Where both join, there is a small membraneous appendage, called the *ligule*. The sheaths arise from the nodes and form tubes protecting the stem. If a young Paddy plant is cut lengthwise, as in the illustration fig. 134, the sheaths will be seen to form a hollow space, in which the stem (*St.*), the younger leaves, and also the flower-buds (*Fl.*) are enclosed. These parts are so extremely tender that even a feeble breeze could break or the heat of the sun scorch them. *The sheaths* of the older leaves that rise above them thus *form a protection to these tender parts*. Only when they have attained sufficient strength, do they grow out of their protecting cover. Besides, they afford the culm more spport, which it requires very much, as those parts of it which lie immediately over the nodes continue to grow for a longer period. This is a peculiarity of the grass-culm. We know that the stems and stalks of other plants grow only at their ends; *the stems of the Grasses,* however, *grow above every node,* a fact which explains why Grass plants generally have such a rapid growth. A Bamboo stem, for instance, has been known to grow 3 feet in 24 hours.

The *blade is linear* and waves like a flag in the wind. Consequently the wind meets with no resistance from it and cannot easily overturn the plant. The *nerves* or ribs of the leaf run *in parallel lines* from the base to the tip of it, in accordance with its linear structure (fig. 135).

The ligule between the sheath and the blade prevents the

rain-water running down the leaves from entering under the sheath and thus rotting the tender parts of the culm.

If the leaves are drawn swiftly through the hand, they cut. This is due to the presence of *silica,* a substance, which constitutes some of the hardest stones like quartz and flint, and is deposited in large quantities in the cell-walls of the epidermis of the leaf and stem. This is certainly not without its good purpose. The hard silica is not only a means of support to the plant, but protects it also from the attacks of a number of small animals, such as snails, caterpillars and insects, that would feed on the leaves and stalks but for this substance which interferes with their feeding. Bigger animals, like cattle, do not mind it. But there are genera of Grass on the Ghauts which are disliked even by cattle for their coarseness.

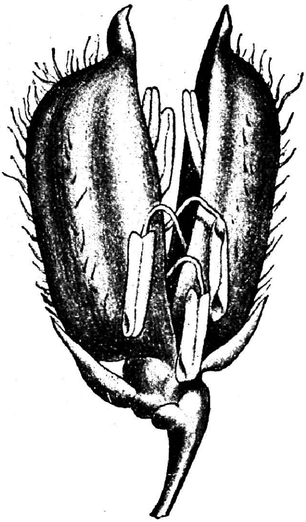


Fig. 136.—The flower of the Paddy Plant (very much enlarged).

5. We now come to the **Flower** and **Fruit.** The flowers are supported by a panicle which bows down with the weight of the ripening grains. The short lateral flower-branches are wiry and bear one-flowered, stalked spikelets. The flower-leaves, generally called *glumes,* are hard, dry, and scaly. We can distinguish an outer and an inner pair. The former are very small, the latter, larger and boat-shaped. These enclose the inner organs, consisting of 6 stamens and the pistil with 2 feathery styles. The larger of the 2 inner glumes which embraces the opposite smaller one with its incurved edges, sometimes ends in a bristle, called an *awn* (fig. 130, 4).

We know that, if seeds are to be produced, the pollen of the

stamens must fall on the style of the pistil. The two glumes that enclose these organs, therefore, open when the organs are sufficiently developed. There is a wise arrangement in the Grass flower in order to make it open in proper time. It would be quite useles for it to open during the rain, for the rain would wash the flower-dust away, and the pistil could not be fertilized. There are, therefore, 2 small, glabrous, fleshy scales, called *lodicules,* within the 2 firmly closed flower-glumes. They swell when the sun shines warmly on the flowers and press the glumes slightly open, so that the 6 stamens can protrude their anthers. The wind then takes the pollen and carries it to the next flower, which catches it readily with its *feathery styles.* After this the anthers fall off, the lodicules shrink, and the glumes close again, like two lids, and under their protection the fruit ripens. The husks remain on the seed even when the latter drops from the plant. They keep the seed nice and dry. When it is sown in wet land and has absorbed moisture, the husks keep the moisture within them for the growth of the embryo even when the soil becomes dry for a while.

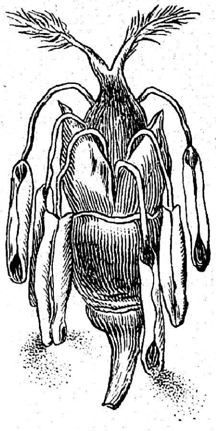


Fig. 137.—The flower of the Paddy Plant. The glumes are removed so as to shew the 2 lodicules and the inner, reproductive organs.

6. **Enemies.**—From the seed-bed to the granary this plant is surrounded by a host of enemies, against whom the cultivator has to wage war: numberless ill-weeds misappropriate its light, space, and food in the field; parasitic Fungi, of which Rust, Smut and Bunt may chiefly be mentioned, settle on culm, blade and flower; grubs and other larvæ of several insects feed on its roots; birds and other animals eat away the ripening grain; and even in the godowns rats, white-ants, the grain weevil, and other uninvited guests can do a great deal of damage to the stored rice.

Other Grasses.

1. **Wheat** (*Triticum vulgare,* Plate No. 626 — *Can.* Gōdi; *Mal.* Kōtampam; *Tam.* Gōdumai; *Tel.* Gōdhumalu). Among the cereals, cultivated in India, Wheat comes next in importance to Rice. It yields a fine, white flour, which is used for baking bread and for preparing starch.

2. **Maize** or **Indian Corn** (*Zea mays,* Plate No. 631 — *Can.* Mekkejōḷa; *Mal.* Ponticcōḷam; *Tam.* Mokkāicōḷam) is of American origin, but is now largely grown in India. As the few roots developed under the ground are not sufficient to fix the robust culm, with its long, ribbon-like leaves, strong enough in the ground, the lower part of the stem forms adventitious roots (Plate 625, fig. 1), which, like the ropes of a flag-staff, hold it firmly. Unlike all other grasses, Maize is monœcious. The male flowers (fig. 2, 3, 4, 5) are at the top of the plant in a large panicle, the female (fig. 6, 7) are produced lower down in the axils of the leaves and form dense spikes, enclosed in numerous sheaths which protect the coverless pistillate flowers. But as the stigma must be exposed to the wind (why?), the styles are drawn out into long filaments, which protrude from the top of the sheath like a long, silky tassel. The large, mostly yellow grains are densely packed on a thick core, thus forming what is known as a cob. A longitudinal section through a grain (fig. 138) shows the oblique germ at the base of copious endosperm.

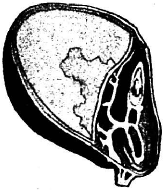


Fig. 138. — Longitudinal section through a grain of Maize.

Maize is a good food for men and domestic animals. The stalks are valuable as fodder, especially when the cobs are disposed of in the green state.

3. **Other Cereals** grown in India are

Indian Millet (*Sorghum vulgare*— *Can.* Biḷē jōḷa; *Mal.* Cōḷam);

Barley (*Hordeum hexastichum*—*Can.* Javegōdi; *Tel.* Yavalu; *San.* Yava);

Oats (*Avena sativa*—*Can.* Tōkēgōdi);

Ragi (*Eleusine coracana* — *Can.* Rāgi);

Little Millet (*Panicum miliaceum* — *Can.* Bagaru); **Italian Millet** (*P. italicum* — *Can.* Navaṇe); and *Panicum frumentaceum* (*Can.* Sāme).

4. **Sugar-cane** (*Saccharum officinarum*, Plate No. 631.—*Can.* Kabbu; *M.* Karimbu; *Ta.* Karumbu; *Te.* Čeruku; *H.* Gannā).—This plant is indigenous to India and yields a higher proportion of sugar than any other plant cultivated for sugar. The perennial root-stock produces numerous, solid culms growing to a height of 10 feet which bear tufts of leaves and a spreading panicle of glumaceous flowers (fig. 139, 2 and 3) at their end. As the old leaves fall off and leave scars, the nodes of the culms become visible. The internodes (fig. 139, 4) are often striped with various shades of red and green.

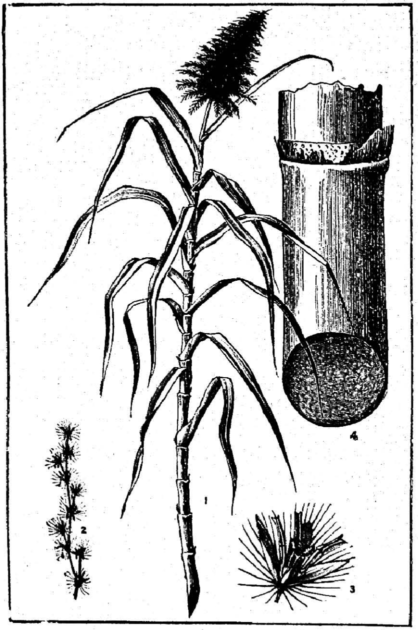


Fig. 139.—The Sugar-cane (*Saccharum officinarum*). 1. Flowering cane. 2. Part of panicle. 3. Single flower. 4. Culm, showing solid consistency and node.

The canes are cut before flowering, as the juice is then in greatest perfection. They are divested of their leaves and of their tops, which contain little or no sugar, and are then crushed in the sugar-mill so as to obtain the sweet juice. This is mixed with lime,

boiled down, clarified, and then cooled, and taken to the market as refined sugar.

5. **Bamboo** (*Bambusa arundinacea* — *Can.* Biduru; *Mal.*, *Tam.* Mūṅgil; *Tel.* Veduru; *Hin.* Bhāsā). — 1. The larger type of

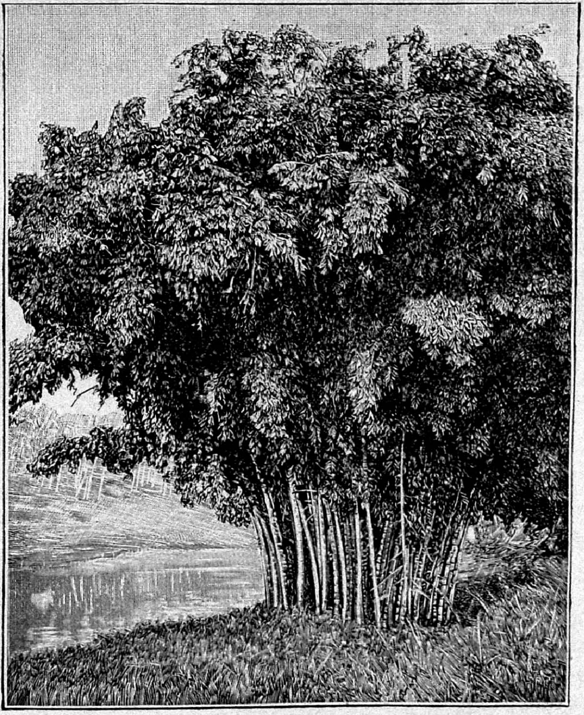


Fig. 140. — A Bamboo Clump (*Dendrocalamus giganteus*).

this genus grows either in *isolated clumps* (fig. 140), or in extensive forests allowing no other trees to associate with it. The smaller species are found as underwood scattered in the forests.

2. The numerous **Stems** of a bamboo clump (fig. 140) spring from a large underground stem. In sandy and dry soil they attain a height of about 10 feet, but in muddy soil they may become 100 feet high. The culms are about 3 inches in diameter, with the nodes rather near one another.

The stems in the centre of the clump are vertical, those at the outer edge hang over giving the whole group a graceful appearance.

The lower part of the stem is commonly branchless, and often spiky from rudimentary hard branchlets. The lowest nodes are set with a ring of numerous adventitious roots which when they do not reach the earth sometimes turn into spikes.— The upper part of the culm bears branches issuing from the nodes in semi-whorls. When these are young they point upwards and enable the stem to find its way up through the thicket: when old, they spread, bend down, and lean on any stems below them. When the wind moves the culms, they rub against one another and produce a groaning sound which is familiar to people who live near bamboo-thickets.

3. In August and September **Young Stems** appear from the root-stock. The rapidity of their growth is astonishing. The rate of it can be ascertained by taking measurements everyday. These tender culms produce, at their nodes, imperfect leaves, *viz.*, sheaths with no blades, which serve as protective covers. When the internodes are full-grown these become useless and drop. The leaves at the ends of the culm are complete. These, too, are shed in the dry season, a peculiar feature in the Bamboo, unlike other grasses.

4. The **Flowers** are produced in branched spikes clustered round the nodes. They are generally monœcious. Stamens 6. Style with a feathery stigma.— Bamboos flower rarely. But when they flower, they do so throughout the whole country at the same time. It has been observed that 32 years lapse from one flowering year to the next; for the years 1804, 1836, 1868 and 1900 have been the years when the Bamboo was in flower during the last century After flowering the root-stock seems to be entirely exhausted, and produces but small and weak culms. Slowly

but gradually its vigour is restored so that only after the lapse of 32 years flowers and seeds can be produced again.

5. The **Uses** of the Bamboo are nearly as manifold as those of the Cocoanut tree. The stems are used for building houses, sheds, bridges, for manufacturing all sorts of furniture and household articles; young sprouts are eaten as vegetable, and the seeds afford a nutritious food like rice.

6. **Spinifex** (*Spinifex squarrosus*—*Can.* Rāvaṇa gaḍḍa).

1. **Habitat.**—Every one who has once strolled along the sandy seashore of India is well acquainted with the spiny, bluish

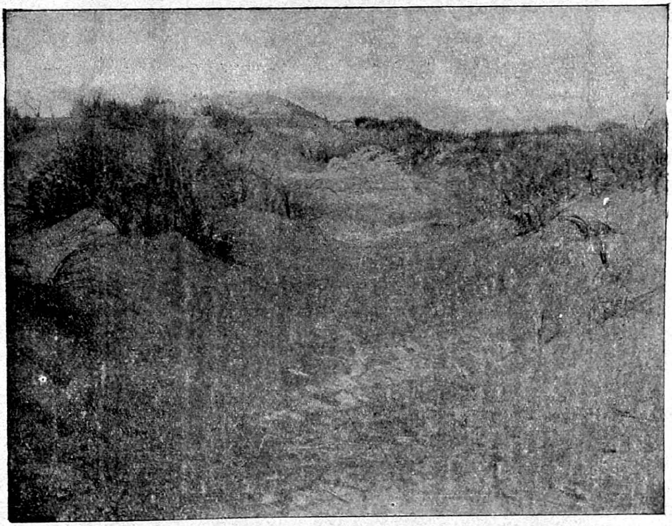


Fig. 141.—Dunes with *Spinifex squarrosus*.

grass Spinifex and its spherical inflorescences. Spinifex sometimes covers the outer dunes in innumerable, apparently isolated tufts. On closer examination it will be found that they are not single but connected with one another by horizontal runners hidden

under the sand, as thick as a goose quill or a finger. These produce roots and side-shoots at their nodes. The leaves owe their pale colour to a thick coat of wax.

2. **Adaptations.**— Spinifex is well adapted to its peculiar habitat. The fixation of the plant in the loose subsoil, the supply of water under adverse circumstances, the constant battle against the sea-breeze to which it is exposed, as well as the taking advantage of this very breeze for the dispersal of its seeds, are shown to great perfection in this plant.

(*a*) *Fixing in the soil.*—Not only are various stocks connected with one another by strong runners, but they are also strongly fixed in the sand by numerous, deep roots which sometimes attain the length of 10 feet and more.

(*b*) *Supply of water.*—The roots penetrate the sandy soil in every direction and reach a depth where the soil is always wet. Thus the plant is supplied with water. But that water is saltish. If much salt is absorbed, the growth of the plant is hindered (see Mangrove, page 47). The leaves, therefore, have not only a large water-storing tissue in them, which keeps the solution of salt at a low percentage, but they are also protected against a great loss of water through transpiration by means of that bluish coat of wax spreading over the epidermis.

(*c*) *The plant and the wind.*—Such a xerophilous structure is also necessitated by its constant exposure to strong breezes. For the same reason it must be strongly rooted in the loose sand, as seen above. As the plants are not tall, the wind can do them very little harm. On the contrary, they take advantage of the wind in letting it tear off the mature globular fruits from their dried stems. Rolling and dancing, the fruit-balls are carried away over the smooth sandy plain, dropping one seed after another on their way. By and by, the bristles between which the seeds lie, are worn away, and they are finally buried under the sand with the rest of the seeds.

7. **The Distribution of the Grasses.** — We have seen that the greater part of the food of man is derived from plants belonging to the family of the Grasses. It is, therefore, no matter of astonishment to learn that the Grasses, such as Rice, Wheat.

Millets, cover the larger part of our cultivated areas. Grasses form the extensive meadows spread out over hills and dales; they inhabit the soft swamps as well as the beaten ground of the way-side; they thrive in the cool shade of jungles and on the scorched heath, on the sandy soil of coast tracts and on the rocky ground of mountains, in the arctic zone under snow and ice as well as in the torrid zone under the parching heat of the sun; they form the extensive tracts known as the Prairies in North America, the Pampas and Llanos in South America, and the Steppes in Europe and Asia: *of all the families in the vegetable kingdom the Grasses occupy the largest area of the fertile parts of the world.*

40. The Pine Family.

(Coniferæ.)

This family belongs to a group of families (*Gymnosperms*), quite distinct from the families we have described heretofore (*Angiosperms*). The distinctive feature of the Gymnosperms is in the seeds, which are not enclosed in an ovary, but are naked. The Conifers are inhabitants of the temperate and cold latitudes. Some of them are successfully planted on the high hills of India, *e. g.,* the Goa Cypress (*Cupressus glauca*).

Woods of Casuarina (*Casuarina equisetifolia*) bear a striking resemblance to the Pine forests of northern regions. The tree does not, however, belong to the Gymnosperms, but to a distinct family (*Casuarineæ*) of the Angiosperms, allied to the Urticaceæ. It is leafless, the branchlets being green and cylindrical with sheaths of scales at the nodes. "The branches, when gently swayed by the wind, give out a sound like that of the sea on a beach, very pleasing to the ears of exiled islanders." The flowers are monœcious. The tree is originally Australian, but now extensively cultivated in many parts of India as a remunerative fuel-tree.

DIVISION II.

FLOWERLESS PLANTS (Cryptogamæ).

These are plants without flowers. They multiply by spores, seed-like cells, that contain no separate germ like the seeds of the flowering plants.

The chief classes of this division are: the Ferns, plants with distinct stems and leaves and with vascular bundles; the Mosses, also with distinct stems and leaves, but without vascular bundles; the Fungi, without distinct stems and leaves.

41. Ferns (Filices).

Most of the Ferns live on shady and moist ground. One of the commonest on the West Coast of India is the creeping **Maidenhair Fern** (*Adiantum caudatum* — *Can.* Čeḷukoṇḍi, Ānekivi), which we can find on every wall and rock during the monsoon.

1. **Stem.**—The stem of this Maidenhair Fern is a small, creeping root-stock, just on the surface of the soil in which it grows, with a bundle of small, fibrous roots. In the rainless season the plant withers down to its tiny stem in which its life is perpetuated.

2. Its **Leaves** or fronds, as they are called in ferns, are exceedingly *thin and tender*. The plants do not require a thick epidermis on their leaves to lessen the glare of the light or to reduce the action of evaporation; for they grow during the monsoon, when the sun is mostly screened behind clouds and there is always sufficient moisture for their growth, both in the soil and the air.

The tenderness of the leaves, however, involves the danger of their being torn by the wind. This is somewhat removed by the division of the leaves into a number of small segments: the leaves are *pinnate,* and the leaflets become smaller as they get further away from the base of the petiole.

When the leaves grow out of the root-stock, they are *rolled up*, the very delicate parts of the young leaf-blade being inside and the strong and hairy leaf-stalk outside. When the latter unrolls itself, it first pushes aside the leaf-mould that may lie over it, and then gradually spreads its soft and thin blade to the light. A peculiarity of the fronds of this plant is that they end in a long tail which bends down, seeking the ground, and strikes root to produce a new young plant at its tip (fig. 142).

Fig 142.—Creeping Maidenhair Fern (*Adiantum caudatum).*

3. **Reproductive Organs.**—The leaves, developed at the end of the monsoon, have small growths on the margin of the lower side of the leaflets (fig. 143). They are green at first, but soon become brown and then look like withered

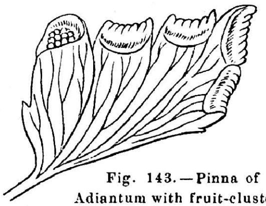


Fig. 143.—Pinna of Adiantum with fruit-clusters.

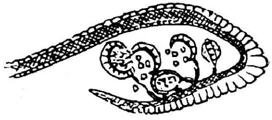


Fig. 144.—Section through the fruit-cluster of Adiantum showing the spore-capsules.

fringes. If we examine these growths, we find in them clusters

of brown capsules, each about the size of a grain of sand. A lupe or, still more, a microscope will show that the capsules have the form of a biconvex lens, with a ring of thickened cells. If they are gently heated on a dry slide over a spirit-lamp and then quickly observed, we can notice how the ring of marginal cells is suddenly straightened and thus causes rupture of the thinnest point of the ring, and how it recovers its original curved position with a sudden jerk, by which the spores in the capsule are forcibly thrown out. This can only happen in dry weather when the wind can disperse the seeds. The spores are so minute and light that the wind can carry them far and wide to places at a distance from the mother-plant, where they settle and, under favourable circumstances, *i. e.,* at the beginning of the following monsoon, develop into fresh, little plants, which, however, are quite unlike the mother-plant. For they produce no stems and fronds, but have a minute, leaf-like body on which the essential organs of reproduction, male and female, grow. If we sow the spores on damp earth and keep them moist and sheltered from direct sunlight, they will germinate, and after a few weeks the surface of the soil will be found covered with small, green, flat bodies, each of which is an individual little fern and develops those organs of reproduction. It is from the spores resulting from the fertilization of the female organs that the first type of the plant arises. *Ferns,* therefore, *pass through two successive states, one of them being a*

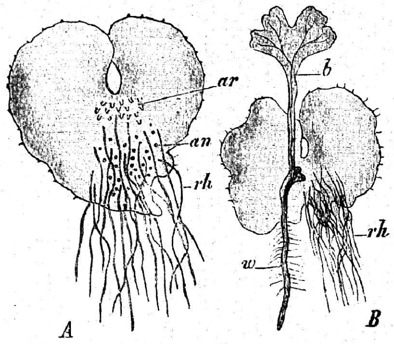


Fig. 145.—The flower-bearing type (called Prothallium) of a fern. *A*. Prothallium from the lower side. *ar*. Female, *an*. Male organs. *rh*. Roots. *B*. Prothallium with a young fern growing from a fertilized ovule. *b*. First leaf, and *w*. root of the spore-bearing other type of the plant. (About 8 times enlarged.)

plant of considerable size and consisting of root, stem, and leaves with spores, and the other being very small and developing sexual organs from the seeds of which the first type again grows.

4. **Distribution and Classification.**—This large order of plants is represented in nearly all parts of the earth, but in the tropics, and there especially on islands and coast tracts, they grow with

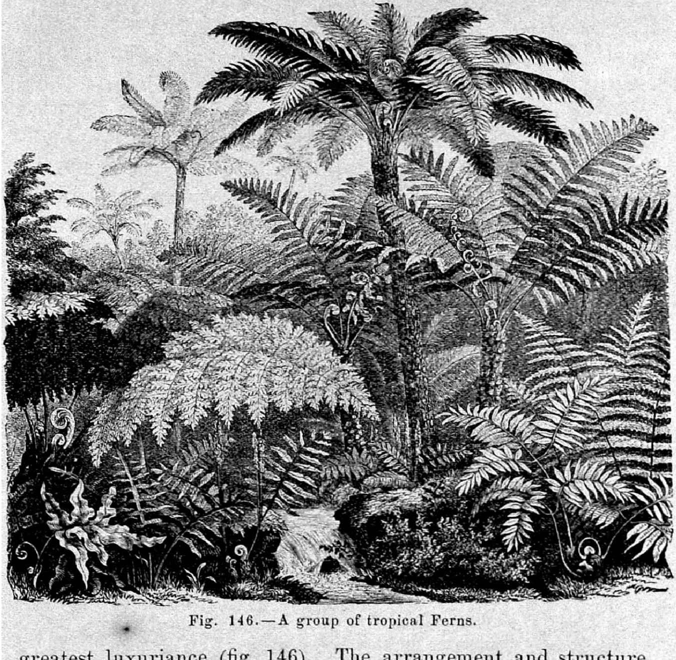


Fig. 146.—A group of tropical Ferns.

greatest luxuriance (fig. 146). The arrangement and structure of the fruit-clusters on the fronds are the characteristics by which the Ferns are classified. They are roundish, uncovered and scattered on the under surface of the fronds: in the genera *Polypodium* (compare the epiphytical *P. quercifolium,* fig. 147), *Gleichenia;*—seated on the margin of the fronds and covered: in *Pteris, Adiantum,* and the creeping *Lygodium;*—cup-shaped

and seated marginally: in *Davallia, Trichomanes,* and *Hymenophyllum;*—in continuous lines on each side of the mid-rib and covered: in *Blechnum;*—linear and scattered over the under-surface and covered: in *Asplenium* and *Athyrium;*—globose,

Fig. 147.—*Polypodium quercifolium*, epiphytical on the branch of a tree.

mostly on the back of leaf-nerves, with or without a cover: in *Aspidium* and *Nephrodium;*—sterile and fertile fronds are distinct: in *Acrostichum;*—the fruit-clusters cover only the upper parts of fertile fronds: in *Osmunda.* *Cyathea* and *Alsophila* are arborescent.

Much richer in Ferns was the earth in ages gone by, when many Ferns grew as large as trees, the atmosphere being then

much damper and warmer than now. The falling stems of such tree-ferns were floated together by mighty streams, carried away to the sea, and buried under sand and mud. The remains of these plants, thus being shut out from the air, could not rot, but were slowly changed into *coal*. The impressions or casts of leaves and stems of Ferns can be distinguished in many pieces of coal even now (see fig. 148).

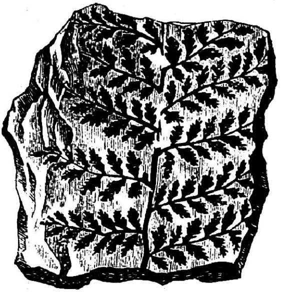


Fig. 148.—A piece of coal with the impression of a Fern.

5. **Allied groups** of plants are the **Water-Ferns** (*Hydropterides*), the **Selaginellas** (*Selaginellaceæ*), and the **Club-Mosses** (*Lycopodiaceæ*). A representative of the Water-ferns is *Marsilia,* a pretty creeping plant with quadrifoliate, folding leaves, common in rice-fields and shallow ponds. The Selaginellas are recognized by their many-branched stems covered by small alternating leaves. They spring up during the monsoon between Ferns and Mosses on earth walls. The Club-moss is likewise a denizen of moist soil. Selaginella and Club-moss have terminal clusters of spore-cases, whereas Marsilia has them hidden near the root.

All these families, together with the Ferns, form one large division of the cryptogams, called *Pteridophyta.*

42. Mosses (Musci).

1. **Their Mode of Living.**—The Mosses live in large groups or colonies and form beautiful, green carpets on moist rocks or on humid and shady ground, and fantastic ornaments on the trunks and branches of trees.

The fronds of the Maidenhair Fern, as we have seen, are not in a position to live during the dry season. As they are unprotected against dryness, they have to wither and can continue their lives only through spores or through their root-stocks,

which bring forth new fronds in the following rainy season. Mosses, however, are so constructed that their leaves simply fold and shrivel up during dry days and recover again after any refreshing shower of rain.

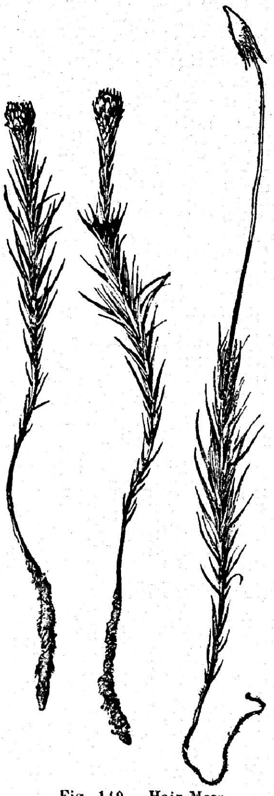


Fig. 149.—Hair-Moss (*Polytrichum commune*).

2. **Structure.**—A Moss plant consists of a short *stem*, decaying slowly at its lower end and continually growing at its upper, leafy end. It has no proper roots; but the lower end of the stem is covered with a growth of brown, felt-like hairs (fig. 149), which penetrate the soil and act like root-hairs, absorbing water and food-substances.

The *Leaves* at the upper end of the stem are of small size and simple form. They are arranged in a spiral. As they are very numerous and as Moss plants grow together in colonies, the rain water that falls on them is not only absorbed by the leaves in large quantities, but it is also retained in the spaces between single plants and between their leaves and stems.

Leaves and stems, when examined under a microscope, are found to be composed only of cells. They contain no vessels at all. Hence they are termed *Cellular Plants*. All the plants which we have hitherto noticed consist of cells and vessels, and are, therefore, called *Vascular Plants*.

If a group of Mosses, say of Hair-moss (*Polytrichum commune*), is examined, we shall find

(*a*) some specimens with merely a bud, composed of young leaves;

(*b*) other specimens bearing, at their upper end, cup-like rosettes of leaves, which assume a bright-reddish colour and protect the minute reproductive organs (fig. 149, to the left);

(*c*) other specimens again bearing at their tips long-stalked spore-capsules, which we shall now study a little closer (fig. 149, to the right).

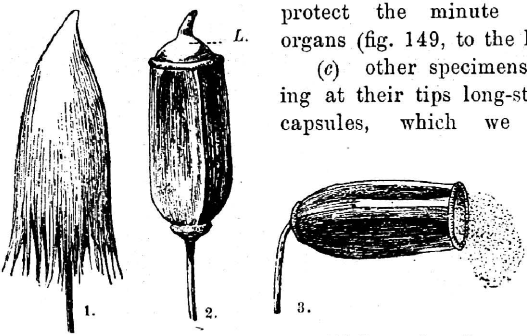


Fig. 150.—Capsule of *Polytrichum* (15 times enlarged).
1. Capsule with hood (*calyptra*); 2. Capsule without it; *L.* Lid.
3. Lid fallen off; the wind sheds the spores.

3. **The Spore - Capsule.**— Both Ferns and Mosses are reproduced by spores. The Ferns, as we have seen, form the spores in clusters of spore-cases generally on the under side of the leaf; the Mosses, however, throw up a stalked, urn-shaped body from the centre of the stem, in which the spores are produced. This little vessel is protected by a dry, fibrous hood (*calyptra*), like the thatch of a hut (fig. 150, 1).

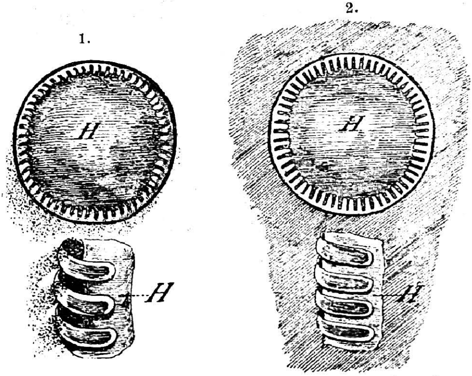


Fig. 151.—Upper face of capsule (30 times enlarged).
1. When air dry: teeth loose, spores issuing between teeth and membrane (*H*); 2. when damp: teeth tight, holes shut up.

When the spores are ripe, the hood is thrown off. The capsule, shut up by a small, pointed lid (2), now appears and soon places

itself horizontally (3). The lid eventually drops also and discloses a pale-grey membrane, attached at its margin to the capsule by a number of tiny teeth (fig. 151). These teeth are very susceptible to moisture. When they get wet, they bend, and while bending press the membrane down, thereby completely shutting up the capsule with the spores. When dry, they stretch themselves upwards and lift the membrane over the brim of the vessel. If the wind then shakes the capsules on their tall, brown stalks, their contents pour out, and a cloud of yellowish or greenish powder (the spores) is carried away to some spot where a new colony of Mosses will soon spring up.

4. **Distribution and Classification of Mosses.**—The Mosses are more conspicuous in the mountainous parts of India than in the plains. Those in the plains are dwarfed as the conditions there do not favour their regular growth. They come during the monsoon and wither with the cessation of rain. The commonest in the low lands are *Garckea,* growing on the earth, about $\frac{1}{2}$ in. high, and having the spore-capsule hidden in the terminal leaves of the stalk; *Hyophila,* growing chiefly on laterite rocks with very short stems and slender spore-capsules about 1 in. high; *Calymperes,* on the bark of trees, very short and reproducing itself by forming buds from the tips of its leaves; *Fissidens,* a minute plant with Fern-like prostrate leaves. The commonest hill Mosses are the terrestrial *Polytrichum, Pilopogon, Pogonatum,* and the epiphytic *Thamnium, Penzigiella, Meteoriopsis, Papillaria,* etc. An allied group of plants are the Liverworts (*Hepaticæ*) which, together with the leafy Mosses *(Musci),* form the division *Bryophyta.*

5. **Importance of the Mosses in the Household of Nature.**—Mosses play a very important part in the household of nature. First of all, the Mosses are among the *first settlers* on bare rocks. Being very small plants they content themselves with the smallest amount of earth, collected in the crevices or uneven parts of rocks; the old parts of the Mosses die off, form vegetable mould, and thus continually increase the little amount of humus in which they rooted at first. They thus gradually form a soil in which other, more highly developed plants can grow.

We have seen that Mosses generally grow not as single plants, but in groups, thus forming extensive, soft cushions. These cushions *absorb and retain the rain-water like sponges and give it off very slowly*. Thus the rivers and streams are kept supplied with water throughout the year, and the valleys through which they flow are rendered fertile. Mosses generally live together with trees and are abundantly found in forests, the shade and dampness of which is advantageous to their growth. Inversely they *help to keep the ground from drying up too soon* and thus are useful to the trees which shelter them.

These facts help us to understand why the keeping up of forests is so beneficial to a country. They represent a reservoir of water, which is filled when it rains, and gives the water slowly off to the rivulets and streams, thus watering cultivated lands when there is no rain.

43. Mushrooms and Moulds (Fungi).

The Mushroom (*Agaricus*).

(*Can.* Āḷimbe, Nāyikoḍe.)

1. **The Mushroom forming the Fructification of a Fungus.**—The Mushroom is a pale, soft substance, reminding one of a diminutive umbrella, with a short, stout stem and a large, horizontal head, at the under-side of which numerous vertical plates, radiating from the stem, can be distinguished. If the head of a mature Mushroom is laid on a sheet of white paper for a few hours, the paper will be covered with the dark powder of minute spores, produced between the laminated parts of the head. As long as the spores are not mature, those delicate parts are covered and protected from the effects of bad weather by a veil, which later on breaks away from the stem and leaves a ring-like scar on it (fig. 152).

2. **The Mycelium.**—The Mushroom grows from a dense network of white filaments, called the *mycelium*. The latter lives under the soil and grows continually, whereas the Mushrooms produced by it here and there are short-lived and perish as soon

as they have strewn out their spores. The whole may, therefore, be compared, *e. g.*, to a Mango tree bearing numerous fruits which are dropped when they are ripe. *The mycelium is the fungus proper, and the Mushrooms are merely the fructifications. The plant lives under the soil; the fructifications, however, are raised above it in order that the wind may disperse the spores.*

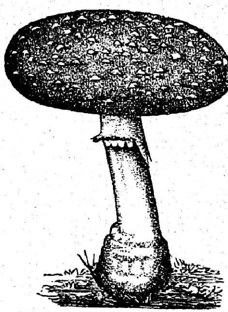


Fig. 152.—The poisonous Toadstool *(Agaricus muscarius).*

3. **Its Mode of Living.**—Like the roots of higher plants the filaments of the mycelium permeate the soil in every direction and draw their food from it. But, as we have seen on different occasions, the roots of plants take up only water and salts. These substances rise into the upper parts of the plant and are there, together with the carbon obtained from the carbonic acid gas of the air, converted into all those substances from which the body of a plant is built up. This work is done by the chlorophyll in the presence of sunlight.

But there is *not the least trace of chlorophyll* in a fungus. The Mushroom is, therefore, obliged to take its food up in a ready-made form; and it finds this in the decaying animal or vegetable matter of the soil in which it grows. It is a *saprophytic plant.* Mushrooms can, therefore, grow only in places where such decaying matter is found. They do also not require any light for their growth, like plants with chlorophyll, and hence can be found in the darkest places.

4. **Importance of the Fungi in the Household of Nature.**—As we have already seen, the Mushrooms decay very soon and thus convert the animal or vegetable substances on which they grow, into nourishing matter for other plants. They may, therefore, be considered as helps to accelerate the process of decay, and are thus of great service to the animal and vegetable world.

On the other hand, many fungi are injurious to man, as they destroy large quantities of agricultural produce, timber, and

other substances, when circumstances favour their development. Among these we mention the *Blights* which, as Bunt and Smut, destroy the grain in the ear of Paddy, and the *Moulds* which are so difficult to combat in the monsoon.

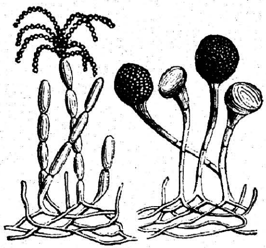


Fig. 153.—Mould with mycelium and fructifications (100 times enlarged).

44. Lichens and Algae.

The **Lichens** (*Lichenes*) represent a certain class of fungi which associate with another cryptogamic class, the **Algae,** to have a common household ("symbiosis"). Like all green plants, the Algae which are green are capable of forming the substances required for the building up of their tissue. Hence they live also by themselves on stones, walls, trunks of trees, etc. The fungus, however, is dependent on ready-made food. It takes such from the Algae which it densely covers with its mycelium. In return, the fungus supplies its purveyors with raw food (*i. e.,* water and minerals dissolved in it), protects them from exsiccation and fastens them to the rock, or the trunk of a tree. The Lichens, which are commonly known by their grey colour and their crust-like, leafy or shrubby appearance, form with the Mosses (page 183) the very outposts of vegetation, growing at the expense of the atmosphere, and the moisture and dust which it bears to them. In course of time they make the hardest rock habitable for higher organisms, and thus show, once more, that in nature the smallest things are often of the greatest importance.

45. Bacteria.

(Schizomycetes.)

A. **The Structure of the Bacteria.**—

1. These plants are *the smallest organisms* known. Many of them are so small that 25000 of them arranged end to end would not measure more than an inch. If examined under the

microscope, it is found that each of them is made up of one cell. They assume various shapes: some appear like globules, some like short sticks, others are long and straight, others, again, spirally-wound. They are generally called "bacteria" or "bacilli", words meaning sticks or little rods.

2. Under favourable conditions they *multiply by splitting in two*. And they multiply at such an enormous rate that, if the conditions remained favourable, one such minute thing would in the course of less than 6 days swell to a mass larger in bulk than the earth itself. This is, of course, never possible, for the food they require for their incessant multiplication would soon fail. But we can see from this example the tremendous rate at which they increase. If the conditions under which they live become unfavourable, they assume a shape that enables them to lie passive until the conditions again become favourable for the continuation of their life.

3. We have seen how small these plants are and can now understand that dry Bacteria can be easily whirled up by the wind and carried away thousands of miles. As invisible dust they are *present everywhere* in the atmosphere, and return to the earth when the air becomes calm.

B. **The Activity of the Bacteria.**—

1. The Bacteria, like the Fungi, lack chlorophyll; they are, therefore, dependent upon ready-made nourishment, animal or vegetable, which they obtain easiest in *decaying matter*.

(*a*) A simple experiment will, however, soon teach us that they do more than merely feed on decaying matter. We take two glass flasks with a little water, into which we put some animal substance. Then we close both flasks with a loose wad of cotton wool. The contents of one flask we leave undisturbed, but the other one we boil for some time, so that the Bacteria in it may be killed. The Bacteria cannot resist the temperature of boiling water any more than other organisms. After a day or two we shall find the contents of the unboiled flask begin to decay, that in the other one remaining unaltered. But if we remove the stopper from it, so that any Bacteria from the air can enter into it, decay sets in here likewise. This shows that the Bacteria do

not only live on decaying substances, but that they are also *the cause of decay.* In other words: *there would be no decay on the earth without the Bacteria.*

(*b*) Suppose the latter were the case: Millions of corpses of animals and plants would cover the earth without decaying. This would result in the destruction of vegetable life, as plants could not find the required food in the soil which is produced by such decay. And in consequence of the destruction of vegetable life also the animals could no longer exist. It is the Bacteria which cause decomposition, and thus are the chief cause of the *eternal cycle of matter in nature.*

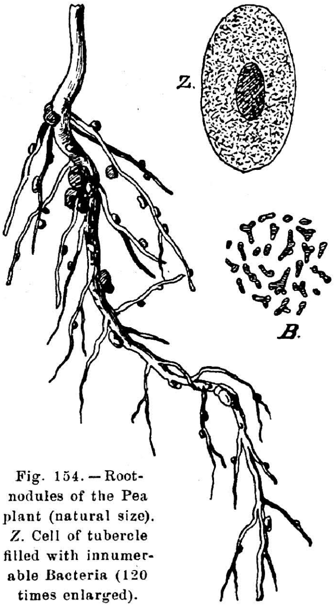


Fig. 154.—Root-nodules of the Pea plant (natural size). *Z.* Cell of tubercle filled with innumerable Bacteria (120 times enlarged). *B.* Bacteria (800 times enlarged).

(*c*) In this connection we may consider a very important thing referring to agriculture. Each time the crop is removed from a field, a large quantity of nitrogen, deposited chiefly in the seeds, is taken away from the field together with other nourishing elements of the soil. The plants are not able to absorb from the air the nitrogen which they cannot do without. It must, therefore, be restored somehow, and this is done by manuring the field. If, however, fresh manure is used, plants will not grow well, and often die. The albuminoids contained in fresh manure must be rendered soluble in order to be of use to plants. This is done by the Bacteria in the soil by decomposing them. *Manure is thus, by the agency of Bacteria, transformed into such a state that it can be used by the plants as nourishment.*

(*d*) Plants are, as has been just remarked, not able to take their supply of nitrogen from the air which has such an abundant quantity of it (about 79%); certain Bacteria form, however, an exception. They grow as parasites on the roots of the Leguminosæ and form nodules on them (*cf.* Pea, page 32). These nodules, when squeezed, throw out a sticky fluid which really consists of innumerable Bacteria that can be readily recognized under a powerful microscope. *The Bacteria which form these nodules, are able to derive their nitrogenous food from the air,* which higher vegetation is unable to do. The larger the quantity of root-nodules, the greater the amount of nourishment derived from the air and stored in the soil. The advantage of growing Pulses, Sunn-Hemp or other Leguminosæ, to recoup the land, is explained by the peculiarity of these plants.

2. Certain other Bacteria produce, in the substances on which they live, a change which is not called decay, but *fermentation* (*cf.* page 21). Again, if toddy or wine is allowed to stand open for a few days, it becomes sour. This is also due to the action of some Bacteria. Similarly it is the Bacteria which turn milk sour, or spoil boiled rice and vegetables. By the action of Bacteria the fibres of Sunn-Hemp (*Crotalaria*) are loosened; and also the peculiar flavour of Cocoa and Tobacco is due to the influence of these little organisms which cause fermentation.

3. Plants without chlorophyll find suitable nourishment not only in decaying matter, but also in *living organisms*. It is no wonder that we should, therefore, find numerous *parasites* among the Bacteria. They penetrate the bodies of animals and men, multiply there at a rapid rate, and produce a number of deadly diseases. Of these diseases we shall mention here only these few:—Consumption, of which $\frac{1}{7}$ of all men die; typhoid fever, diphtheria, smallpox, and influenza, which also every year destroy a great number of men in the prime of their life, and cholera and plague, which are the most terrible scourges to which a country can be subjected.

It is right that we should learn to know *how to meet these powerful enemies.* One of the means to keep these "omnipresent" microbes away from us is the greatest *cleanliness*. This holds good of the vessels in which we prepare and

preserve our food, of our houses and their surroundings, of our garments, and, above all, of our own bodies.— As shown in the above experiment, Bacteria perish at the temperature of *boiling water*. This supplies us with a means of keeping good, for some time at least, a number of food substances, such as meat, fruit, vegetables, milk, etc., which would otherwise soon be spoiled.— From immemorial times men have also been using salt to preserve meat and to pickle fruits, sugar to candy them, and smoke to preserve meat. Besides, there are some drugs, called *antiseptics*, which also destroy Bacteria or prevent their action.

SECOND PART.

THE STRUCTURE AND LIFE OF PLANTS.

DIVISION I.

The Minute Structure and Vital Processes of Plants.

I.—THE SINGLE CELL.

1. The illustration of the vertical section of a leaf, as seen under a microscope, shows that the leaf of a plant does not consist of a homogeneous mass like iron or glass, but of several

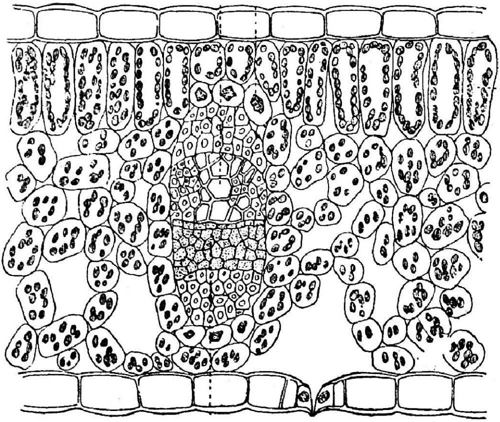


Fig. 155.—Transverse section of a leaf, to show its composition of cells.

small parts, called **Cells,** which like the stones of a wall, constitute the whole. Like the leaf, all the other parts of a plant, *viz.,* root, stem, flower and fruit, are composed of cells.

2. Most plants are thus **composed of numerous Cells.** But many of the lower classes (*e. g., Bacteria*) consist of a **single cell** each. These plants are generally very small.

3. The **Size** and **Shape** of the cells vary greatly. In the Bacteria the length of one is less than ·001 cm, in the fibre of Flax and the hair of the Cotton-seed it extends over 4 cm.

4. In some cases a number of cells standing one over the other in a row have the partitions which separate them removed, and thus form a tube or a **Vessel,** open all through.—*Plants, then, are built up of cells, or of cells and vessels, the latter originating from cells.*

5. The cell consists of a cell-wall and the cell contents, which when young is called **Protoplasm.** This is a viscid, nitrogenous substance, capable of absorbing moisture, of expanding, of forming fresh cells by division, and of motion: it is *endowed with life.* The cells are the workshops in which all the secret and wonderful operations of the plant-life are carried on.

6. By the activity of the protoplasm certain substances are produced, which are of great importance to the life of the plant. Some of these are green granules, called **Chlorophyll,** which give the plants their green hue. The chlorophyll-granules have the power of forming starch under the action of sunlight out of carbonic acid gas and water absorbed by the plant.

7. Besides, the cells contain a fluid, called the **Cell-Sap,** in which acids (Citron!), salt, sugar, and other substances are dissolved. This sap rises from cell to cell permeating through the cell-walls from the root to the top of the tree. The protoplasm forms various substances out of the cell-sap, which together with the starch are either passed along to any point of activity where their presence is necessary for the growth of the plant; or they are stored up in the tissues of the plant for future use. In this way oily and fatty matters, and grains of albuminoids are formed and stored.

2.—THE ORGANIC STRUCTURE.

1. Plants which consist of *single cells,* like the Bacteria, can be compared to single men who live for themselves and have to do everything alone, such as gathering of food, building of houses to live in, defending themselves against enemies and so on. So single cells have to do all the functions essential for life: they have to absorb their food, to build up their structure, to guard against adverse circumstances, and to reproduce their kind.

2. Plants consisting of *various cells,* however, are like a state, in which the different labours conducing to the welfare of the community are divided. As in the state certain individuals (farmers) are occupied in obtaining food for all, others (craftsmen) in supplying the public with houses and clothes, others (merchants) in the distribution and circulation of food and articles, and others (soldiers) in the maintenance of order and in the defence of the common-weal, so the various cells of a plant are assigned different functions and form a well-organised state.

3. They are also specially fitted for their several special purposes, and groups of them thus form *organs* for the vital operations of the plant.

These organs are not equally developed in all plants. Some have a higher, and some a lower organisation. We shall now study the various organs of the plant, as we find them in their leaves, roots, stems, flowers, and fruits.

DIVISION II.

The Structure and Vital Processes of the Parts of Plants.

I. THE LEAF.

A. The Outer Structure.

1. **The Parts of a Leaf.**—The chief parts of a leaf are:

(*a*) the **stalk** or **petiole,** which supports the leaf;

(*b*) the **blade,** which provides a large surface exposed to the action of light and air, so as to enable the plant to evaporate its water and to gather as much carbonic acid gas as possible.

The stalk helps to place the leaf always in a position to get a large share of sunlight and air (*cf.* Cucumber, page 57; Sunflower, page 65); it also prevents the blade being torn by the wind or by raindrops (*cf.* Mango, page 23). Some leaves have no petioles, *e.g.,* Ixora; they are then called *"sessile"*. Many plants have *sheathed* stalks surrounding the stem, as for instance, the Grasses (*cf.* Rice, page 164). The petiole is attached either to the bottom of the blade, as in most plants, or in the centre of it, as in the Castor-oil plant, and in this case it is called *'peltate'*.

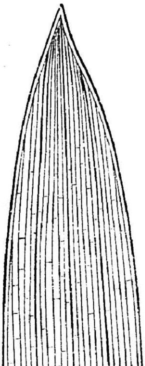


Fig. 156.—Tip of a Grass blade with parallel veins (4 times enlarged).

Fig. 157.—Piece of the leaf of a dicotyledonous tree with reticulated veins (reduced).

(*c*) In the Rose, the Pea, and other plants leafy attachments will be noticed at the bottom of the leaf-stalk just where it parts from the stem. These are called **stipules.**

2. The Blades of Leaves exhibit various **Characteristics:**—

(*a*) As to the **arrangement of the ribs** or veins. If we examine the leaves of Grasses, or Lilies, we shall find that the veins run parallel to one another in one direction from the stalk to the tip. The venation of such leaves is said to be *parallel.* The veins in most dicotyledons, such as the Teak and Banyan, form a kind of network; they are called *net-veined* (reticulated fig. 157).

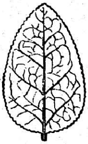


Fig. 158.—Ovate leaf.

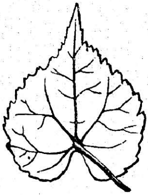


Fig. 159.—Cordate leaf.

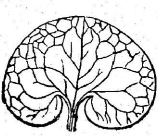


Fig. 160.—Reniform leaf.

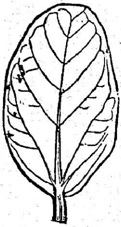


Fig. 161.—Elliptic leaf.

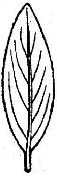


Fig. 162. Oblong leaf.

Fig. 163. Lanceolate leaf.

In most net-veined leaves we can distinguish one main rib which is the continuation of the leaf-stalk. Such is called a mid-rib. The side-ribs branch off from the mid-rib like the hairs of a feather. Such a leaf is said to be *feather-veined* (fig. 162). In other leaves, as of the Cucumber, or the Ricinus, the leaf-stalk branches into five, seven or more ribs which spread out like the fingers from the palm of the hand. Such leaves are *palmate-veined* (fig. 159).

(*b*) As to **form.** Some are egg-shaped or *ovate;* some heart-shaped or *cordate* (Betel, Portia tree); some kidney-shaped or *reniform* (Hydrocotyle—*Can.* Ondelaga); some *elliptic* (Banyan); some long and narrow or *oblong* (Mango); some shaped like the head of a lance or *lanceolate* (Leucas—*Can.* Tumbe); and some needle-shaped or *linear* (Asparagus—*Can.* Halavumakkaḷatāyi).

(*c*) As to their **margin**, whether *entire* (Jack); or *toothed*, with teeth pointing outwards (Clerodendron—*Can.* Iṭṭēvu); or

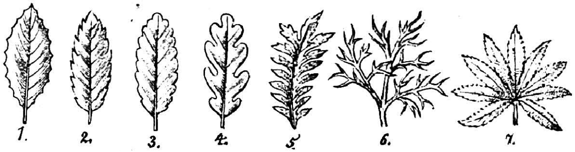


Fig. 164.—Margin of leaves: 1. Dentate (toothed); 2. serrate; 3. crenate; 4. sinuate; 5. pinnatifid; 6. bipinnatifid; 7. digitately lobed.

serrate, with teeth like a saw pointing upwards (Rose); or *crenate*, with rounded teeth (Ageratum—*Can.* Urāḷagiḍa); or *sinuate*, if the edge is not toothed, but has broad and shallow depressions (Papaw tree); or *pinnatifid*, if the leaf is cut half-way down and

Fig. 165.—Trifoliate leaves of Horse gram.

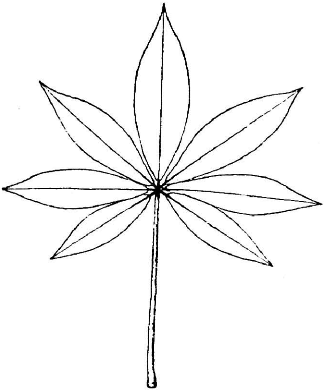


Fig. 166.—Digitate leaf of the Silk Cotton tree.

the divisions are narrow and acute; or *bipinnatifid*; or *digitately lobate* (Castor-oil plant).

(*d*) As to **division**, whether simple (Jack, Banyan), or compound, that is, formed of separate pieces (Rose, Tamarind).

(*e*) If compound, whether the leaflets are *trifoliate* (Gram);

or *digitate,* that is, spread out like fingers (Silk Cotton); or *pinnate,* with a terminal leaflet (Rose, Clitoria), or none (Pea); or *bipinnate,* when the divisions of pinnate leaves are themselves pinnate again (Peacock's Pride, Acacia); or *tripinnate, i.e.,* three times pinnate (Drumstick tree).

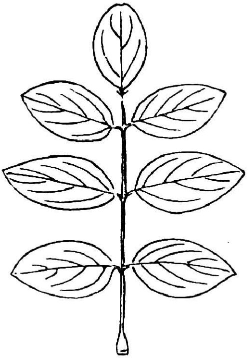


Fig. 167.—Pinnate leaf of Clitoria ternatea.

(*f*) As to **surface,** whether *smooth* (Mango), or *rough* (Jack), or *glabrous* = free from hairs (Tumbe), or *hairy* (Nettle), *pubescent* = downy (Til), *tomentose* = woolly (Gnaphalium), or *glaucous* = with a coating of wax (Poppy), or *glandular* (Sundew).

3. The **Insertion of the Leaves in the Stem** is such as to prevent any interference with one another, and thus to allow free access to both light and air.

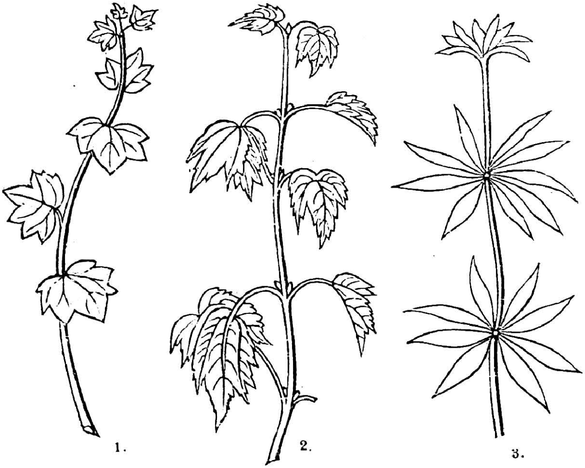


Fig. 168.—Insertion of leaves: 1. alternate; 2. decussate; 3. whorled.

They are either *alternate* (Custard Apple), or *opposite* when the leaves are in pairs all up the stem, one on each side of it; or *decussate* when each pair of opposite leaves is at right angles to the next pair (*Labiatæ, Verbenaceæ*); or *whorled* (Alstonia — *Can.* Hālēmara). If we repeat the experiment with the thread, described on page 65, we shall see that those seemingly irregular leaves are inserted in the stem in *spirals*. With the help of the thread it is also easy to find out how many turns are necessary to get to a leaf which is exactly above the first, and which of the number of leaves it is. Thus we count 5 leaves on 2 turns in the case of the Jack tree, or in the Shoeflower; each leaf, therefore, takes $\frac{2}{5}$ of a turn. The arrangement of leaves is in this case denoted by the fraction $\frac{2}{5}$. Grasses and Lilies have their leaves generally in the $\frac{1}{2}$ position; other common positions are those represented by the fractions $\frac{1}{3}$ and $\frac{3}{8}$.

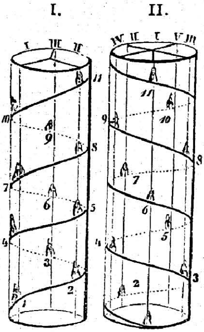


Fig. 169.—Spiral insertion of leaves. Each leaf takes $\frac{1}{3}$ of a turn in I, and $\frac{2}{5}$ in II.

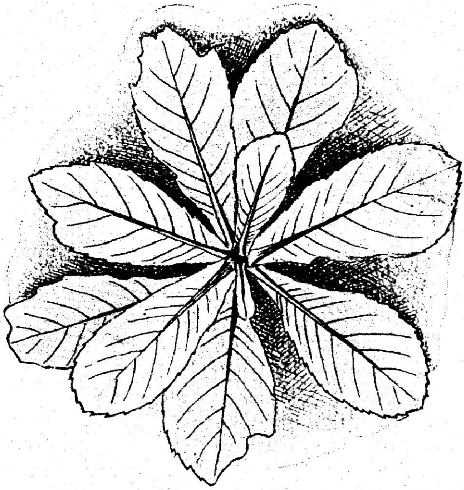


Fig. 170.— Leaf-rosette of Elephantopus.

The stem of Elephantopus (*Can.* Nelamuččala) is so short that the leaves appear to grow all from one point. Such leaves are also arranged

in spirals; they form what is called a *radical leaf-rosette* and show very plainly that the leaves so arranged allow one another their due share of light.

4. **Buds.**—The shoot of a plant always ends in a bud, consisting of undeveloped leaves folding over and *protecting the growing point of the shoot.* Plants which grow in cold countries have their buds protected by hairy and resinous scales. In Indian plants buds are mostly naked. Exceptions are the Pea (p. 31) and the Banyan tree (p. 111), whose buds are protected by stipules.

The young and tender *leaves are variously arranged in buds:* they are folded like a sheet of note-paper (Rose, Elephant-Climber), or plaited like a fan (Cocoanut tree), or rolled from side to side (Lotus), or from top to bottom (Ferns), or crumpled (Cabbage).

Besides the *terminal* bud, there are *axillary* buds, borne in the axils of leaves, from which branches originate. Axillary buds do not all open but sometimes remain dormant (*sleeping buds*), until one day the top of the stem is cut off. Some trees, as Palms, never develop any other than terminal buds.

5. **Some peculiar kinds of Leaves.**—Leaves sometimes assume modified shapes, and might be mistaken for distinct structures, as in the *tendril* of the Pea, or in the *thorns* or spines of Cactus, or in the *bladders* of Utricularia.

All tendrils, however, are not modified leaves. Those of Passiflora, for instance, are arrested branches. So are also the spines of the Lime tree transformed branches. The prickles of the Rose or of Lantana are neither leaves nor branches, but growths of the bark, like hairs.

B. The Work done by the Leaf.

1. Transpiration or Evaporation of Water.

(*a*) **The Fact that Plants evaporate Water** can be proved by an experiment. Place some fresh twigs of a plant under a bell-jar in the sunshine. After a short time we shall find a deposit of moisture on the inner side of the glass. Another bell-jar with no

plants under it, similarly placed in the sunshine, has no such deposit of moisture. From this we draw the conclusion that plants transpire or evaporate water in the form of water-vapour.

(*b*) **How can this Transpiration take place?**—A careful examination of the surface of leaves shows that there are many tiny openings which, looked at through a microscope (fig. 171), appear like little mouths, and are therefore called *stomata* (from the Greek *stoma,* mouth). Some leaves have them on both sides, but most only on the under side. (The Lotus plant cannot but have them only on the upper side. Why? Compare page 3.) These openings lead to hollow spaces, called *air-chambers* in the interior of the leaves (see fig. 155 on page 190). The stomata are the "gates" of these cavities, through which a great deal of the water in the plant escapes as vapour. In a lesser degree transpiration also takes place through the walls of the cells of the outer skin, called *epidermis.*

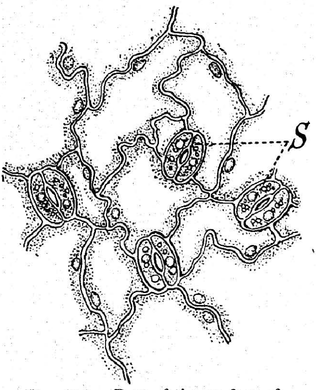


Fig. 171.—Part of the surface of a leaf. *S.* Stoma (200 times enlarged).

(*c*) **Importance of Transpiration.**—This process is of the greatest importance to the life of the plant. It is generally known that plants suck up water and mineral food dissolved in water by means of their roots. This liquid food is carried up through the stem and the branches to the leaves, where, as we shall see later on, certain materials which the plant requires for its growth, are formed. All the water that comes up is not required for this purpose. When it has done its work as carrier of the mineral food from the soil to the leaves, it is passed off as vapour, making room for further supplies from the soil. The transpiration of water from the leaves thus *acts like a suction pump: it is always drawing up fresh supplies of water and food from the roots.*

(*d*) **Amount of Transpiration.**—We can ascertain the quantity of water evaporated by a certain plant in a given time, by means of a simple experiment. We put the stem of a twig with leaves into a tumbler of water, cover the surface of the water with a coat of oil and place the whole on a balance. After a few hours we shall notice a considerable loss of weight, due only to the evaporation of water through the leaves of the plant. Thus, for instance, it was found out that a Sunflower plant gives off a quart of fluid in 24 hours, and a Teak tree many gallons in the same time. A piece of land covered with trees brings an enormous amount of water up from the depth of the earth to the atmosphere. From this we may now easily understand, how important woods are for the fertility of a country, and how disastrous it is to destroy forests. In each plant an invisible stream of water arises, as it were, from the ground to pour in the ocean of the atmosphere to come down again to the earth as rain.

The amount of evaporation varies with certain circumstances. In the first place, it depends on the temperature: the warmer the air is and the hotter the leaves become under the rays of the sun, the more rapid will be the action of transpiration. Secondly, when the wind blows and carries away the air round the leaves which is saturated with vapour, bringing dry and thirsty air ready to take in vapour from them, the amount of evaporation will naturally be greater than when there is no wind. Thirdly, clothes dry much more slowly during the monsoon than when the dry land-wind blows. For the same reason plants will evaporate much more water in dry weather than in the monsoon. When the air is saturated with moisture, *e.g.*, in the cool morning of a monsoon day, no water can be evaporated from the leaves. Some plants, as Kesu (*Colocasia*), Maize, Bamboo, are able to press the water out from little pores at the tips and edges of their leaves. These drops of water hanging from the tips of the leaves should not be mistaken for dew-drops.

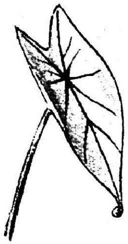


Fig. 172.—A drop of water oozing from the leaf of *Colocasia*.

(*e*) **Helps to promote Transpiration.**—As the evaporation of

water through the pores of the leaves is of such great importance to the plants, we find many arrangements in the the plant-world by which this process is enhanced when likely to prove useful to the plant.

Plants that grow on shady and moist places have *large leaves,* as a rule, and generally very numerous stomata. Their leaves are, besides, very tender, that is to say, their *epidermis is so thin that water can pass* not only through the pores (stomata), but also *through the walls of the surface cells.*

We can sometimes see dark spots or blotches on the leaves of some plants, such as some Aroideæ or Turmeric. *By virtue of these dark-coloured spots the leaves are enabled to absorb more heat* than if they were green throughout. (A dark coat feels warmer than a bright one.) Similarly, the leaves of the Lotus plant are coloured dark-purple on their under side.

Many plants, like the Bean and almost all Leguminosæ, have the curious habit of *folding their leaves at night.* This, again, is an ingenious device to prevent dew from covering them and thus choking the pores, so that the action of transpiration may not suffer (see page 36).

Other plants, like the Opium Poppy, possess a *bloomy coat of a waxy substance* on their leaves so that they are not wetted, and the process of evaporation may not be interrupted.

Most leaves *taper into a point* instead of having a blunt end. This enables them to become dry soon after the rain ceases, as the raindrops fall easily to the ground from such tapers.

Plants that grow under favourable conditions of water-supply are termed *Hygrophytes.*

(*f*) **Means to check too much Transpiration.**—Too much transpiration, *i. e.,* too great a loss of water is, on the other hand, dangerous for the life of a plant. Plants, which have to live on very dry soil, or are exposed to the scorching heat of the sun or to the parching influence of dry winds, or which for many months must do without a drop of rain, must needs have some means of reducing the action of transpiration.

Above all, we notice that the leaves of such plants have a very *limited surface* (*cf.* Leucas, page 98; Asparagus, page 145),

and are sometimes reduced to mere spines or scales (Cactus, page 54; Casuarina, page 173). Some plants drop their leaves entirely during the dry season (Teak, page 105; Silk Cotton tree, fig. 173) to prevent loss of moisture by evaporation.

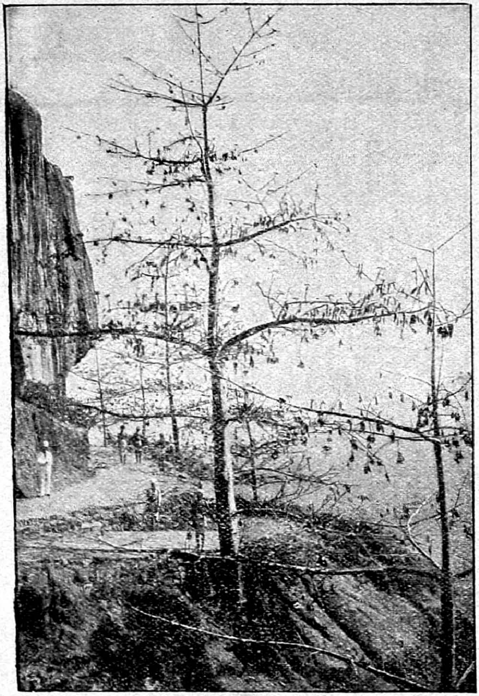


Fig. 173.—The Silk Cotton tree in the dry season: leafless but fruit-bearing.

Another kind of protection from the scorching heat of the sun is the *vertical position* of leaves, as is seen in many trees of Australia, of which the Eucalyptus tree is one. Instead of holding their leaves flatly or horizontally, as trees generally do so

as to catch every ray of sunlight, they avoid the heat as much as possible by holding them edgeways to the light. Similarly some other plants, like Oxalis (*Can.* Puḷḷampuṇise; *Mal.* Puḷiyāral; *San.* Čukrikā) fold their leaves at midday when the sun shines hottest.

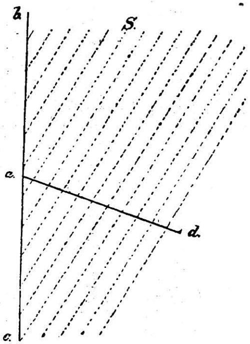


Fig. 174.—Solar rays striking the line *a d* at right angles and heating it much more than the lines *a b* or *a c* which lie more in the direction of the sun's rays.

Various plants that live on dry and rocky soil, store up in their *fleshy stems and leaves* every drop of water they can get when rain falls, and live sparingly on it during the long periods of drought which may last for three-quarters of the year. Such plants are the Bryophyllum (*Can.* Kaḍu-basaḷe), the Agave (*Can.* Āne-kattāḷi), and many Spurges and Cactuses. A number of Orchids make the same provision for long periods of drought in using their enlarged stems or pseudo-bulbs as storehouses of nutriment and water, upon which the plants feed in times of need.

And not only are these plants thus enabled to store up water against the time of drought, they also keep this precious fluid under a *thick, leathery skin,* through which only very little moisture can escape.

Another very common means of protection against too great a loss of moisture by transpiration is the *hairy covering* of their leaves. The hairs keep a layer of quiet air within their spaces and thus prevent the access of new, unsaturated air which would dry up the leaves in a short time. (See Til, p. 95; Gnaphalium, p. 69).

Many leaves also are *shiny* and reflect a great deal of the heat which would otherwise raise their temperature, and so increase the activity of evaporation (*cf.* Mango, page 24).

And, last but not least, most plants have the wonderful power of *closing their stomata* as soon as the amount of water coming up from the roots becomes scarce.

Plants with such contrivances to keep down the loss of water to a minimum are termed *xerophytes.*

2. Assimilation of Food.

I. Absorption of Mineral Salts.—

In the preceding chapter we have seen that plants need a constant supply of water. It is known to every one that the water taken up by the roots contains substances from the earth dissolved in it. Which are these substances? If we burn a plant carefully, an ash remains. The minerals constituting the ash, must have been the substances absorbed by the plant. Chemists tell us that the principal minerals found in the ash of plants are *sulphur, phosphorus, potash* or *soda, lime, silex, magnesium* and *iron.* Other substances that formed part of the body of the plant but were dissipated by the heat, are *carbon, water,* and *nitrogen.*

A simple experiment will show that the substances named above, excepting carbon, form the mineral food absorbed by the root. We prepare a solution of 1 gram of potassium nitrate, 0·5 gram of sodium chloride, 0·5 gram of calcium sulphate, 0·5 gram of magnesium sulphate and 0·5 gram of calcium phosphate, in 1000 grams of distilled water, and add one or two drops of iron chloride. If a seedling, say of Pea, is nursed in this food-solution, it will be found that it grows healthily and even develops flowers and seeds. But if one or the other of the minerals is omitted, the growth will be stunted and dwarfed. If, for instance, there be no iron in the solution, the leaves and the stem of the plant will become pale yellow, but they turn green when a drop of liquid containing iron is added to the solution.

The minerals thus absorbed become part of the tissue of the plant and are "assimilated" (from Latin *assimilo* = to make alike).

II. Absorption of Carbon.—

(*a*) **Source of Carbon in Carbonic Acid.**—The greater part of the plant-body, however, consists of carbon (charcoal is carbon). The plant nourished in the food-solution, as described above, could not derive it from the water. It must, therefore, have had some other source of carbon supply.

Atmospheric air always contains more or less (0·03—0·04%) carbonic acid gas, a compound of carbon and oxygen and given off from the lungs of animals and men and from the burning of wood and coal. This is the source of the carbon supply. The leaves absorb the gas, and because there is so little of it, each tree needs to spread out an immense amount of foliage, so that it may drink in all the carbonic acid gas that can possibly be obtained.

Some very instructive evidence is furnished by a small aquarium. If animals, especially fish, alone be kept, it will be found necessary to renew the water daily, or the animals will soon die. If, however, some water plants are introduced, the same water may be kept in for months, and the animals will continue healthy, thus showing that animals soon make the water deadly to themselves, and that plants restore and maintain the balance, evidently taking from the water what the animals give to it, *viz.*, carbonic acid gas.

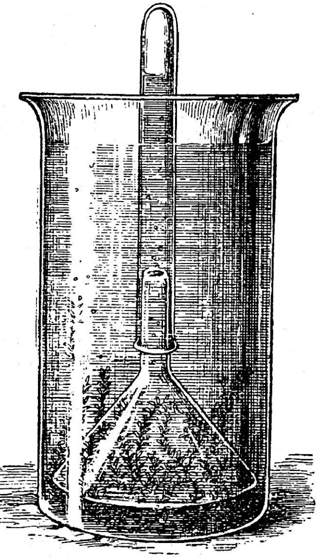


Fig. 175.—Absorption of carbonic acid gas and setting free of oxygen by a water-plant.

That leaves absorb carbonic acid gas, we shall learn from a simple experiment. Take a bunch of fresh green leaves of a water-plant, say Utricularia, and place it under a funnel in a vessel filled with fresh spring water. Over the mouth of the funnel place a test-tube filled with water. Then expose the apparatus to strong sunlight. After a very short time you will see bubbles arise from the leaves, which are collected at the top of the test-tube, as is shown in the figure. When all the water

in the test-tube has been displaced, we shall close it with the thumb, take it out and introduce a glowing chip, which will at once burn very actively: the tube contained oxygen gas. This gas was evolved by the leaves under the water. They absorbed the carbonic acid gas, dissolved in fresh spring water, and retained only the carbon of it, setting free the oxygen.

That this explanation is correct, *i. e.*, that the oxygen set free is derived from the decomposition of the carbonic acid gas and not from the water, may be proved by continuing our experiment. The evolution of oxygen gas will become less and less until it ceases altogether. This can only be due to the exhaustion of carbonic acid in the water.

We know now that *plants possess the power of absorbing carbonic acid gas through their leaves and of deriving from this gas the carbon which they require for the construction of their body.*

(*b*) **Only the Green Parts of Plants absorb Carbonic Acid.**—It must, however, be borne in mind that not all plants have the power of thus feeding on the carbonic acid gas in the air. It is only the *green plants* (name plants that are not green!) and only the *green parts* of these that can feed on the carbonic acid gas in the air. If we repeat the above experiment with a potato tuber, no oxygen will be given off. The green leaves are, therefore, the most important organs of nourishing the plants. Plants which are repeatedly robbed of their leaves, as for instance, by the ravages of caterpillars, become sickly and die.

(*c*) **The Presence of Sunshine is required.**—The green parts of plants can absorb carbon only under certain circumstances. *They require sunshine for their action.* If we place the apparatus of the experiment, described above, in a dark place, there will be no formation of bubbles, and there can, therefore, be no absorption of carbon. At night also this process cannot take place.

The fact that plants require light for their life, explains numerous features of the structure of plants: The green parts of the plants are placed in the light; stems and branches, the supports of the green leaves, rise above the ground; climbers bring their leaves from the shade below to the life-giving light above; many jungle plants that would not get sufficient light on the dark-

shaded ground have assumed the habit of perching on the branches of trees where they have a chance of getting more light; the leaves themselves are generally dark-green on their upper surface and whitish on the lower one; the insertion of the leaves in the stem is always such that all of them get their due share of light; those placed at the base of a stem are in many cases larger, long-petioled and flatly exposed to the light, those above, small and pressed towards the stem (Mustard, Ladies'-finger); if the stem is weak and straggling (Cucumber, page 57), the petioles, by twisting and bending themselves, assume such a position as to place every leaf in the light; and large leaves are often divided into smaller parts so as to let the light pass through their holes to any leaves that grow below them.

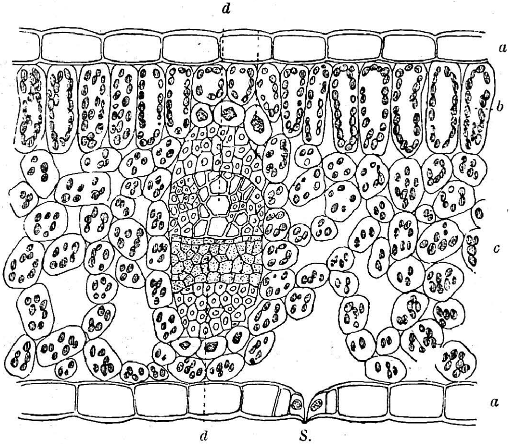


Fig. 176.—Vertical section of a leaf (320 times enlarged).
a. Epidermis. *b*. Palisade tissue. *c*. Spongy tissue.
d. A vein or rib. S. Stoma.

(*d*) **The Inner Structure of the Leaf: Chlorophyll and Assimilation.**—In order to better understand the manner in which leaves absorb their food, we must examine the *inner structure* of them. The illustration given here shows the vertical section of a leaf as seen in a microscope. The upper and the under surface are

formed by flat cells with thick walls. This is the outer skin or *epidermis* (*a*). Between the 2 skins there is a layer, more or less thick, of soft and green tissue, the upper part of which consists of oblong cells, arranged at right angles to the surface, and placed so evenly parallel to each other that they have been compared to the pales of a fence. They are called *palisade tissue* (*b*). Below the palisade tissue is another of a quite a different form, consisting of cells that are not so closely packed, but have large air-spaces between them, like a sponge. They form the *spongy tissue* (*c*). The illustration also shows a bundle of other cells in the middle (*d*). These constitute a vein running through, and supporting, the blade of the leaf. In the cells of the palisade and spongy tissues we can see a number of small, green spots. These denote the *chlorophyll-granules* that give the leaves their green colour. The palisade tissue contains a much greater quantity of them, and this is the reason why leaves are generally dark-green on the upper, and light-green on the under surface. It is in these green granules that the all-important work is done of decomposing the carbonic acid gas into its constituents, carbon and oxygen, and of forming new substances. This process is called *assimilation.* To allow the air to reach the inner parts of the leaf, there are the *stomata* (*S.*) on the under surface of the leaf, which lead into the spaces between the cells of the spongy tissue. And as the walls of the cells, in which the chemical changes are going on, are exceedingly thin, they require protection. This is afforded by the epidermis.

(*e*) **The Substances formed by "Assimilation".**—The products of the process of assimilation, that is, of converting the raw food from the soil and the air into material necessary for building up new tissue in the plant, are chiefly two, namely, starch and albumen. Of these the more important is *starch,* a compound of carbon, hydrogen, and oxygen. This substance abounds within the cells of many parts of various plants, as in the potato and all cereal grains, and is also the principal constituent of arrowroot and sago. The importance of this substance for the life of the plant is duly understood when we learn that the plants need it for the construction of the cell-walls of all their parts. Even

albumen, of which the life-substance of the plant, the protoplasm (see page 191), consists, can only be formed of starch together

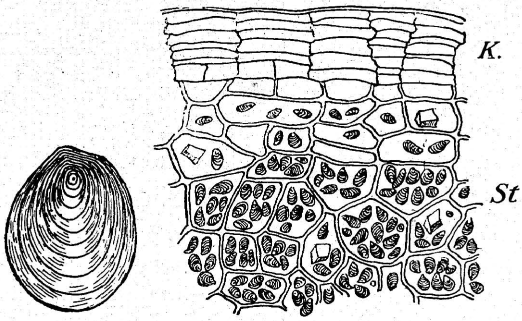


Fig. 177.—Starch in potato.

with other mineral substances obtained from the soil, among which nitrogen is the chief substance. Other organic products formed in the cells, the little laboratories of the plants, are *sugar,* found abundantly in Sugar-cane and all sweet fruits, *oils* and *fats,* common in seeds (Castor-oil, Gingili), *alkaloids* with either medicinal, or poisonous, or stimulating properties (Coffee, Tea), and *acids* (Citron, and many fruits).

The products prepared in the cells of the leaves, are then carried through the ribs and the stalk of the leaf and through the stem to wherever their presence is required. They are also stored up in the stem, in tubers, in bulbs, in roots, or in the seeds, as a reserve of material for future use.

3. Respiration or Breathing.

(*a*) **Proof of the Fact that Plants breathe Oxygen.**—Plants, like animals, absorb oxygen and give off carbonic acid gas, which process is known as respiration or breathing. This cannot usually be observed at the time when the process of assimilation takes place. It is, however, very evident in parts that are not green and in all parts at night. Take, for instance, two narrow-necked

glass bottles of equal size and fill one of them one-third with germinating seeds of Bengal gram or flower-buds. After about a day insert a lighted taper. In the empty bottle the taper will go out after it has burnt a little while, *i.e.*, until the oxygen contained in the bottle is used up by the burning taper. In the other one the taper goes out at once, showing that there is no oxygen in the bottle. The latter must have been absorbed by the growing seeds which gave off carbonic acid instead.

(*b*) **Necessity of Breathing.**—The oxygen thus obtained by the plant is required for burning some of its carbon, by which process heat is produced which is the energy for the various chemical processes carried on in its body to maintain its life and to grow. It is, therefore, evident that plants must breathe at all times and in all their parts which contain living cells, *i.e.*, in their leaves, stems, roots, flowers, and seeds.

In the green parts the action of breathing at day cannot be shown as they assimilate under the influence of sunlight more vigorously than they breathe. They rather appear to exhale oxygen. We have, therefore, to strictly *distinguish between Assimilation and Respiration. While in the process of assimilation green plants alone, and only in the light, decompose carbonic acid and give off oxygen,* **all** *plant organs without exception both by day and by night take up oxygen and give off carbonic acid.*

When the action of breathing is vigorous, *e. g.*, in young leaves, or in wounded ones, it is indicated by a red hue (see Mango, Cinnamon), due to a red colouring matter, called cyanophyll*. This pigment is also present in flowers and fruits coloured red or blue, according as it is dissolved in an acid or alkaline cell sap. It appears, too, in old leaves, painting the foliage of northern forests with that charming red before they drop their leaves.

If plants or parts of them are deprived of oxygen and the action of respiration is thus checked, they are hindered in their growth, become sickly, or perish. This can often be noticed in pot-plants or fruit-trees which are planted too deeply and covered

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* From Greek *cyanos*, blue, and *phyllon*, a leaf.

with too much earth. Their roots cannot get the required air for breathing. Conversely the loosening of the upper crust of soil is advantageous to crops to allow the air free access to the roots.

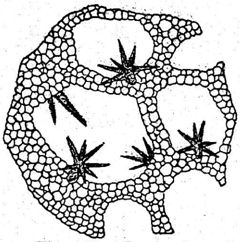

Fig. 178.—Large air-chambers in the leaf-stalk of the Water-Lily, forming air-canals from the leaf-blades to the root.

(*c*) **Ways for Breathing.**—The entrance of oxygen into the plant body is accomplished in the same way as that of carbonic acid for assimilation: It enters through the *stomata* of leaves into the air-chambers inside and is distributed in the tissues in all directions, penetrating into the protoplasm of the inner cells. Stems and stalks that are covered with bark also have their openings, called *cortical pores,* by which the free passage of gases is secured. They appear as small, brown outgrowths scattered over the surface of stems (fig. 179, see also stem of Shoeflower!) and consist of loose cells with large intercellular spaces communicating with groups of cells (called medullary rays) that run through the woody tissue to the centre of stems.

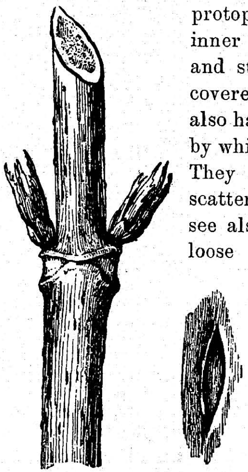

Fig. 179.—Cortical pores in a young stem of Elder. (Nat. size.) To the right a magnified pore.

In marsh and water plants, which stand partially in the air, *e.g.,* the Rice-plant and the Water-Lily, intercellular air-spaces are extensively developed and form connecting canals (compare the leaf-stalks of the Water-Lily) through which the atmospheric oxygen can reach the organs growing deep in the swampy soil which are cut off from any communication with the atmosphere. The roots of Mangrove trees obtain air to breathe by means of special growths thrown up above the level of the water.

2. THE ROOT.

We have seen that the plant derives its food partly from the air and partly from the soil. One part of the plant, therefore, rises above the ground; the other grows downwards, and this part is called the root.

1. The chief **Uses** of the roots for the life of the plant are the following:—

(*a*) they fix the plant in the earth, and

(*b*) they suck up moisture as food and drink for the plant.

2. The **Structure** of the roots is in full harmony with these functions.

(*a*) **Tap-root and Side-roots.**—To anchor the stem firmly in the ground there is not only a *main* or *tap-root,* which in continuation of the stem grows vertically down, but there are also numerous *side-roots.*

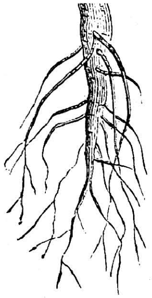

Fig. 180.—Main root with side-roots of Thorn-apple.

The *size* of the root is generally in proportion to the size of the plant, as a large tree necessarily requires a stronger hold in the ground than a small herb. "The astonishing strength of tree-roots can be imagined when we watch a tree in full leaf during a storm. As the terrific force of the gale sways the trunk to and fro, the roots are subjected to an enormous strain. Like great India-rubber cables, they give and retract, and when the wind subsides, we find the trunk as firm as ever." (*Brightwen.*). The side-roots of some trees (*e. g.*, of the Casuarina, of the *Poinciana,* fig. 181, and of many big trees of the forests in the Ghauts) are seen above the ground like huge props to the stem. Cut or sawn across, it will appear that their shape is almost like planks set edgewise. Thus the trees gain in power.

(*b*) **Root-hairs.**—For the purpose of absorbing the food, which must always be in a liquid form, the ends of the roots are covered with fine *root-hairs* (fig. 182), which are really the active part

of the root, for it is only through these hairs that the rootlets can absorb the liquid from the soil.

Common earth consists of small particles of mineral substances, such as clay, lime, or iron, and also of such vegetable

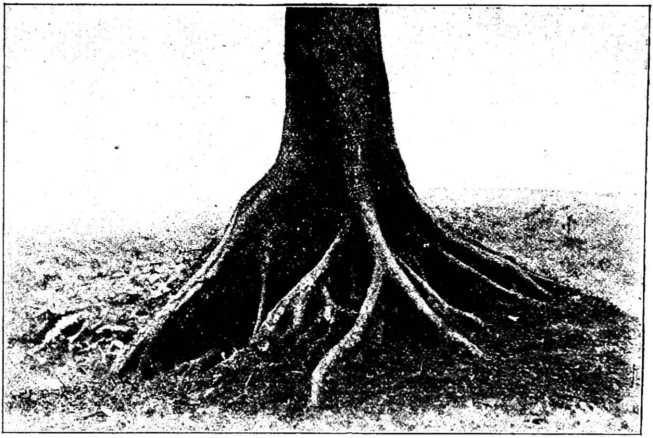

Fig. 181.—Plank-roots of the Goldmohur tree *(Poinciana regia)*.

matter as decayed leaves and rotten wood. The spaces between the particles are more or less filled with air, each mineral particle being enveloped within a film of water which it absorbs from the atmosphere or obtains from the rain-water passing from the surface to the subsoil. It has been ascertained that the root-hairs which penetrate into the smallest crevices of the earth feed only on this delicate water-film which contains mineral substances in solution. And the air in the soil greatly helps towards the oxidation and dissolution of the minerals. For this reason the breaking up of the ground by spade, plough, etc., plays such an important part in agriculture and horticulture. We can now understand also why stagnant water in the ground is so injurious to plant-life. It prevents the needful air from coming

into contact with the roots. This is the reason why farmers are careful to remove the surplus water from their fields by drainage and canalisation.

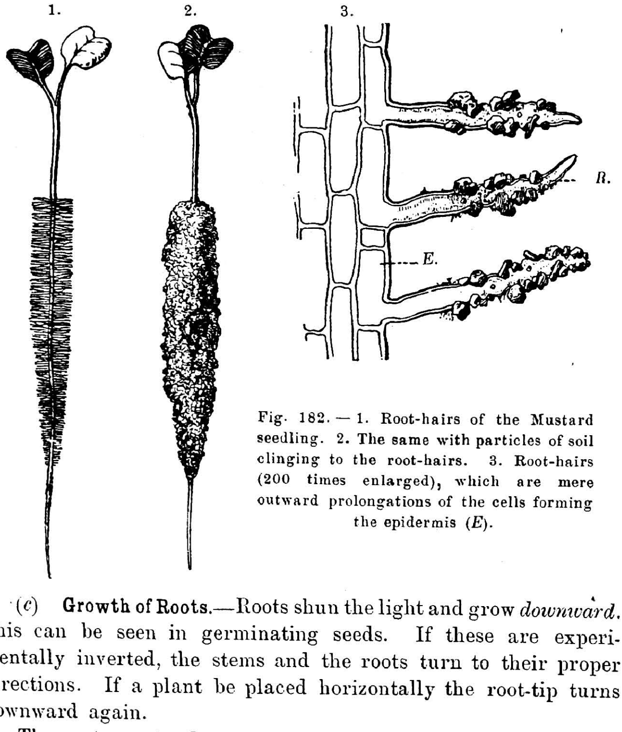

Fig. 182. — 1. Root-hairs of the Mustard seedling. 2. The same with particles of soil clinging to the root-hairs. 3. Root-hairs (200 times enlarged), which are mere outward prolongations of the cells forming the epidermis (*E*).

(*c*) **Growth of Roots.**—Roots shun the light and grow *downward.* This can be seen in germinating seeds. If these are experimentally inverted, the stems and the roots turn to their proper directions. If a plant be placed horizontally the root-tip turns downward again.

The roots *constantly grow* so as to reach parts of the soil from which they have not yet drawn food. Some go right to the depth (*e. g.*, most trees, Spinifex), others feed more on the surface (*e. g.*, Cocoanut tree, Kesu). While pushing their way through the hard soil their tips get worn out. They are, therefore, not only protected at their ends by small *caps,* but these covers are also constantly renewed. The older parts of the root have no root-

hairs (why?), but form a protective covering of bark, like the stems.

(*d*) **Manuring and Rotation of Crops.**—Farmers, who year after year try to grow, on the same field, plants which can feed only on the uppermost layer of earth, must take pains to *manure* the ground after they have taken the crop. For, with the crop they remove also many elements of food from the soil, so that the soil becomes poorer and poorer in the materials available for plant-growth, and the crops gradually deteriorate. But as some plants require more or less of a particular element than others, and also strike their roots more or less deep in the ground, the farmer can *rotate* his crops, that is to say, if Paddy and Pulses, for instance, are grown in a certain field one year, they are followed up the next year by Sugar-cane, and so on, coming back again to Paddy eventually.

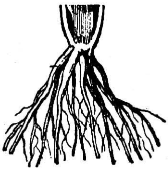

Fig. 183.—Fibrous Roots.

Fig. 184.
Swollen Tap-root of Radish.

3. **Peculiar Kinds of Roots.**—(*a*) **Fibrous Roots.**—Grasses and most of the monocotyledons have a number of similar thread-like roots, among which a main or tap-root cannot be distinguished. Such roots are called fibrous. They are particularly fit to bind earth and sand together to clods, and this tendency of fibrous roots is taken advantage of in the construction of railway embankments by planting grass on the slopes.

(*b*) **Thickened Tap-roots.**—Some tap-roots swell and become a storing place for food material, like the thickened root of the Radish (fig. 184) or of the Four-o'clock plant. In some cases the same thing happens also with side-roots, as in the Dahlia, or in Wild Asparagus (fig. 185).

(*c*) **Adventitious Roots.**—Roots may also be thrown out by the stems of plants, and are then called adventitious, *i.e.*, accidental or out of the ordinary course, as they are not formed

from the original root or portion of it. We can find such roots on the stem of the Pepper vine (page 127), which climbs up with their help; they form the supports of the long, horizontal branches of the Banyan tree, and afford the Mangrove trees (*Rhizophora mucronata,* and others) a better hold in the swamps in which they grow. Many plants creep on the ground and form adventitious roots from the nodes of their creeping stems (*Hydrocotyle, Ipomœa batatas, Ip. biloba, Spinifex,* etc.).

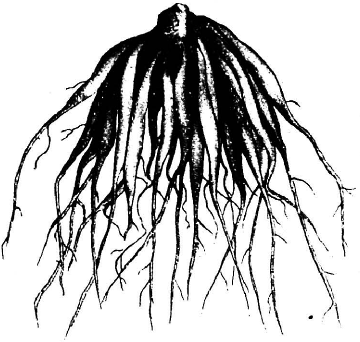

Fig. 185.—Thickened Side-roots of *Asparagus.*

Advantage is taken of this power of forming roots out of the stem in multiplying plants by cuttings.

(*d*) **Aërial Roots.**—These absorb the watery vapour of the air and hang down from perching plants, such as some Orchids. Some kinds of Mangrove (page 51) throw up air-roots above the water-level, which contain large spaces to enable the roots to get sufficient air to breathe.

(*e*) **Parasitical Roots** penetrate into the stems and roots of other plants, instead of drawing their nourishment from the ground. Loranthus and Cassytha drive their roots into the stems, the Sandalwood tree into the roots of other plants (p. 126).

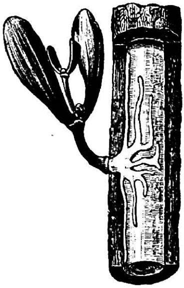

Fig. 186.—Parasitical Root of Mistletoe.

3. THE STEM.

The work of the stem may be said to be threefold. It has

1. to support the branches and leaves, and to spread them out to the air and the sun;

2. to carry the sap from the roots up to all parts of the plant, and to bring the starch formed in the green parts of the plant down to the points where growth takes place;

3. to serve as a food-store for the use of the plant in future.

1. Stems as Means to spread out the Leaves and Flowers to the Air and the Sun.

We have learned that the inner cells of leaves are the workshops wherein the plant prepares materials for the construction of its body. But as this can only be done under the influence of sunlight, and also as carbon can only be taken from the air, it follows that the leaves must be freely spread out to the sunlight and to the air. The same is also necessary for the flowers in order that they may be fertilized by insects or by the agency of the wind so as to produce fruit. *Stems,* therefore, *rise up,* and, in many cases, form branches on which they can support a great number of leaves and flowers.

(*a*) **Herbs, Shrubs, Trees.**—The greater the load of leaves, flowers and fruit which a stem has to bear, the stronger must also be its structure. Comparatively small plants of a short duration of life, the so-called *herbs,* which are either annuals or biennials, thus have a weak, soft, green stem, divided into nodes and internodes. The nodes are the points from which leaves arise, and are often swollen as in Grasses. The internodes are the intervening portions of the stem. They are generally hollow in Grasses, the nodes being solid. *Perennial herbs* have stems which flower and perish annually; but the underground portion of their stems remains alive for an indefinite period.

The stem of a plant that does not die at the end of a season, but lasts for years, becomes woody. If the woody stem of such a plant branches off from the ground, it is called a *shrub;* if it has a distinct woody trunk, scarcely branching from the base and of considerable size, we call it a *tree.*

(*b*) **Creepers and Climbers.**—Some stems, whether herbaceous or woody, are so thin and weak that they cannot stand erect. They **creep** along the ground shooting out roots at their nodes

wherever they touch the ground and thus forming new stations. The Spinifex (*Can.* Rāvaṇa gadda) and the Goat's-foot creeper (*Can.* Aḍumbu) on the sand dunes of the seashore, as well as

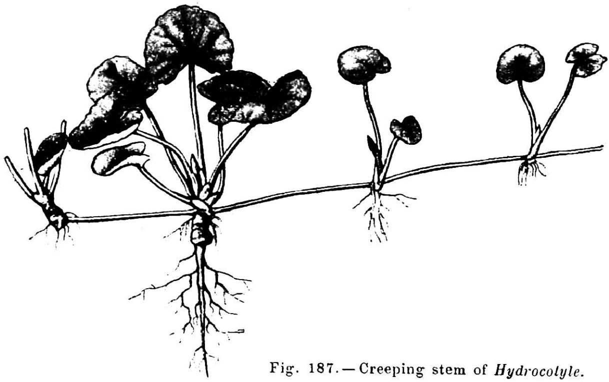

Fig. 187.—Creeping stem of *Hydrocotyle.*

the Hydrocotyle (*Can.* Ondelega), the Sweet-potato (*Can.* Sīgenasu) and many other such plants that grow in unshaded ground, have found it an advantage to spread thus over the ground.

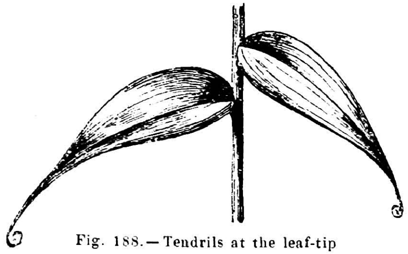

Fig. 188.—Tendrils at the leaf-tip of *Gloriosa superba.*

Other weak stems assume the habit of *climbing* other plants in the shade of which they grow, and thus raise their foliage to the life-giving light. From the various methods by which they climb, they can be classified as follows:—

1. *Root-climbers, e.g.,* the Pepper vine; these produce little roots on the lower side of their stems to attach themselves to the supporting trunk of a tree or to a wall.

2. *Tendril-climbers, e.g.,* the Pea, the Cucumber, the Gloriosa.

These attach themselves to their supports by means of tendrils, which are sometimes merely the tapering ends of the mid-rib (Pea, Gloriosa), sometimes the leaf-stalks (fig. 189), and sometimes separate organs growing from the axils of the leaves (Cucumber, Passion flower).

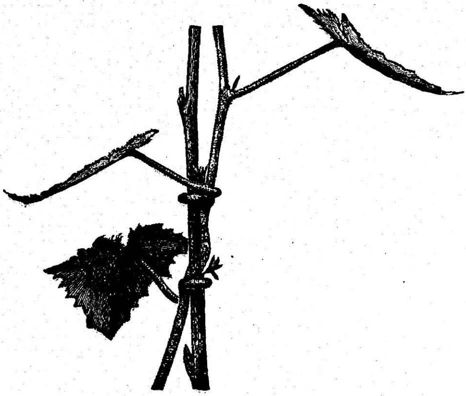

Fig. 189.—*Lophospermum scandens.* The leaf-stalk used as tendril.

3. *Twining climbers.* The stems of these climbers wind round their supports, some in the direction in which the hands of a watch move (Yam), and others in the opposite direction (Bindweeds, Shankapushpa). If unwound and turned the other way, the young parts will insist on following their original direction.

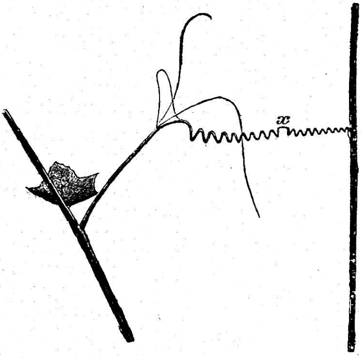

Fig. 190.—Tendril of *Luffa acutangula.*

4. *Scramblers, e.g.,* the Rose, the Wild Asparagus, the Bamboo. These climbers stretch their tips through the holes of the thicket in which they grow and then open their branches wide so that they may not glide down. Hooks and spines are often made use of to the same purpose.

A common feature of these climbers is their quick growth

and the absence of leaves and branches at their tips, called forerunning tips (see page 80).

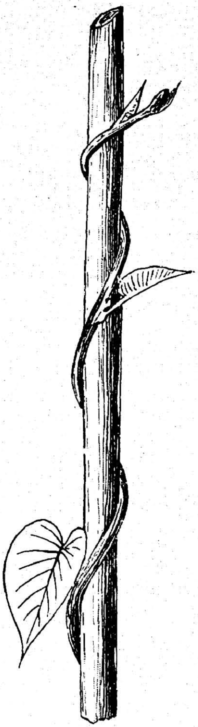

Fig. 191.—Twining stem of *Argyreia speciosa*.

(*c*) **Strength of Stems.**—As the stem with its heavy load of leaves, flowers and fruits, high up in the air, is subjected to the bending, pulling and shearing stress of wind and storm, it must have a certain amount of strength to withstand such stress or possess some other means to lessen the destructive effect of the wind.

Stems are ordinarily not strong enough to stand against hurricanes; their leaves are torn away, branches broken, yea, whole trees uprooted and destroyed. The destructive effect of such a tempest can be specially seen on isolated trees. If they stand in groups, they help one another and resist the storm-wind with their united strength. Winds also change the mode of the growth of trees and imprint in their very faces signs of the hard battle which they have continually to fight against. Such trees follow with their branches the direction of the prevailing winds (fig. 192) or spread out their branches in horizontal sheets instead of growing high and increasing the plane of resistance (page 41). To a certain degree every plant is enabled to protect itself against the destructive stress of the wind: by means of their petioles they place their many leaves in any direction the wind blows and thus escape most of the wind pressure; long linear leaves as those of the Grass family wave like a flag in the wind without opposing it; large trees as those of the Cocoanut tree are slit into numerous segments to allow the wind to pass through; the Plantain allows the wind to tear its broad blade into many pieces for the same purpose. In spite of

all such means there remains a great deal of pressure to which a stem is subjected and it follows that, to bear up against this pressure, it must be specially strengthened. How much the strength of a stem is strained, can be seen in the culm of a Rice plant, which with a diameter of 5 *mm* at its base grows to a length of 1500 *mm*; it is indeed marvellous to see that this slender stem with

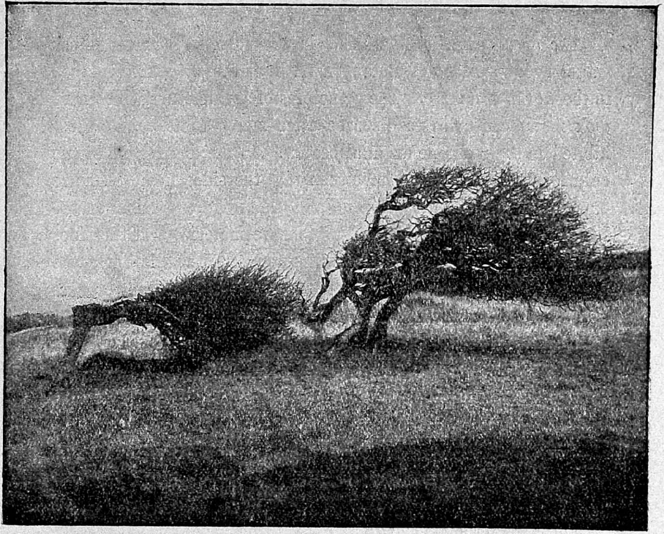

Fig. 192.—Trees deformed by the effect of the sea-breeze.

its heavy load of leaves and grains is not broken when the wind blows at it. What, then, makes the stem of this or any other plant strong enough to hold its own against the weight of the whole plant which presses it downward, against the bending stress of the wind, which tends to break it, and against the pulling power of the wind which tends to uproot the plant?

First of all, it is the thick-walled *woody cells* which not only make up the greater part of the trunk of a tree but are also

present in the annual stems of many herbs. Of equal importance to the strength of the stem are the *bast-cells,* commonly known as fibres, which are to be found in the inner bark of the stems of dicotyledons (see Flax, page 18) as well as in the fibrous bundles of monocotyledons (p. 224). The strength with which the fibres of plants in general resist any pull is equal to that of the best wrought-iron and, in certain plants, even exceeds that of steel.

The arrangement of these cells in the stem is something that makes every student of Botany marvel at the wisdom displayed in the works of nature. The principles of architecture which man took many centuries to discover after many trials are here exhibited in their simple original beauty. In the description of the culm of a Rice plant we have seen that the sides of the stem are exposed to the greatest stress and the middle portion to the least; hence the culm is hollow to save material and the sides are strengthened by a cylinder of strong fibres. Similarly the stem of the Labiatæ and many other plants have their four corners strengthened by strong cells. The strength of beams is proportional to the breadth and to the square of the depth. This rule is illustrated by the edgewise placement of leaf-ribs, *e. g.,* in the Teak, or of plank-roots (see fig. 181). If other plants are examined in this respect, we always find that, though the position of their fibres may be modified, they always answer the fundamental principles of architectural structure.

When the crown of a tree is shaken and the stem is bent by a storm, the roots have to sustain an enormous pull, just like the cables that are used to keep a vessel at anchor. If such cables were untied and their several strands were made to hold the ship, they would be easily torn one by one by the movements of the vessel. As they are united into cables, the pull which would tear the single strands is equally distributed over every one of them, and thus the cable is able to withstand it. Thus in roots we find the woody and bast-cells crowded together in the middle, which makes them strong like cables. The same arrangement of such cells is found in the climbing stems which are also exposed to strong pulls.

2. Stems as Channels for the Ascending and the Descending Sap.

We have heard of the water current from the root upwards to the leaves where the water and the mineral substances dissolved in it are used for the formation of starch and other material required for the building up of tissues. We have also learned that the superfluous water is evaporated through the leaves. Hence there must be a continuous upward flow of water.

On the other hand, we have seen that the substances elaborated in the leaves cannot remain useless in the cells of the leaves, but must be carried to those places where new tissue is formed, such as the tips of the roots. Hence, there must be a continuous downward flow of liquid food-stuff.

We shall, therefore, now proceed to make a study of the stem as a channel for the ascending and the descending sap.

(*a*) **The Inner Structure of Stems.**—A transverse section of a *dicotyledonous tree,* such as the Teak or the Mango, exhibits the following parts of the inside structure:—

In the centre a light, spongy substance, called the *pith* (fig. 193, *c*); closely surrounding this, a harder substance called the *wood,* growing in concentric circles, being hard and dry within, but soft and wet without (*b*); the outer covering, called the *bark* (*a*).

Fig. 193.—Transverse section of the stem of a dicotyledonous tree. *a*. Bark. *b*. Wood. *c*. Pith.

Now, the tenderest part of the whole is that between wood and bark. This is called *cambium* and is the living part of the stem, continually forming new wood, called *alburnum,* and new bark, called *liber* or *bast.* The way in which annual rings are produced is briefly described under the description of the Teak tree (p. 103). Plants whose stems thus grow in girth by the addition of wood from outside under the bark are sometimes called *exogens,* a term synonymous with dicotyledon. The bark cannot expand in proportion to the growth of the wood, and, therefore, has to crack

and split. These cracks do not, as a rule, extend to the delicate cambium which the access of air and heat would partially kill, but stop when they reach the inner layers of bark more recently formed by it.

Not all trees have stems of this structure. Palm trees, like all *monocotyledons,* follow a different plan. Their stem consists of a soft cellular tissue with many woody bundles (consisting of vessels and fibres), so that it resembles a number of sticks bound closely together. There are no concentrical layers of wood, no cambium, no bark, and no pith. As the stem does not increase in girth (by additions to its outside), but only grows in in height and "from a notion that the younger bundles were those in the centre of the stem, and that they pushed and compressed the older bundles towards the outside, the older botanists were led to call such stems endogenous". (Oliver.) The fact that these stems are soft or even hollow within, but hard in the outer part, makes them more pliant.

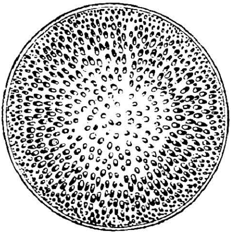

Fig. 194.— Transverse section of the stem of a monocotyledonous tree.

If we compare the large, spreading branches of the Mango or the Banyan with the simple cluster of leaves, at the top only, of the Palm tree, we can understand why their thin, cylindrical stems are sufficiently strong for them.

(*b*) **The Ascending Sap.**— The water current cannot ascend in the heart-wood, the cells of which are generally impregnated with waste products, such as gum and tannin, and therefore impermeable. The dark heart-wood is thus made durable and resists the attacks of fungi which would otherwise cause the wood to decay. This property makes that part of the wood not only useful for the carpenter but also strong enough to support the mighty weight of the branches above the trunk. Some trees, indeed, do not contain such heart-wood, as will be seen in the White Dammar (*Vateria indica,— Can.* Dhupada mara), and, therefore, become hollow when old, the dead wood being destroyed by fungi.

The water current does not rise in the bark also, as can be shown by removing a ring of bark from a branch: the leaves above the wound remain for a time as fresh and green as those below the wound. If, however, the fresh wood below the bark (alburnum) were removed and the bark allowed to stand, the leaves and all the parts above the cut would perish.

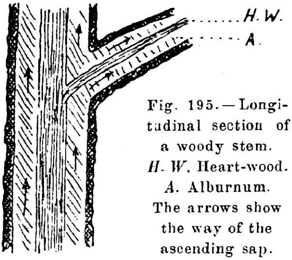

Fig. 195.—Longitudinal section of a woody stem. *H. W.* Heart-wood. *A.* Alburnum. The arrows show the way of the ascending sap.

This shows that the *sap ascends* only *in the alburnum* consisting of cells the cell-walls of which are still tender and allow the sap to pass through, and of tubular vessels through which the sap can easily pass.

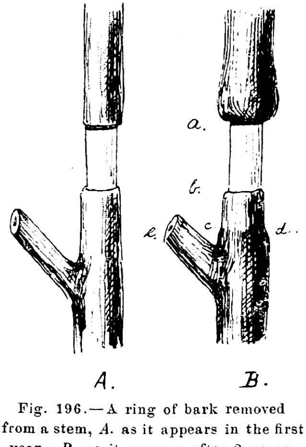

Fig. 196.—A ring of bark removed from a stem, *A.* as it appears in the first year, *B.* as it appears after 2 years. *a b* the bark stripped off, above *a* the stem is swollen by the descending sap, *b c* dry bark, below *c d* the stem has grown in size due to the sap descending from branch *e*.

(*c*) **The Descending Sap.**—The organic compounds formed in the leaves of water and carbon have to be distributed to the places where they are required, *viz.*, the growing points—the tips of stems and roots, flower-buds, fruits, seeds, the cambium layer, and all other places of growth. What the leaves elaborate is mostly starch. But starch cannot pass from cell to cell through the cell-walls. It is, therefore, turned into a liquid, *i. e.*, into grape-sugar, which easily goes through thin membranes like cell-walls. Besides starch, nitrogenous compounds are formed in the leaves. These too have to be conveyed to the growing points. So the question arises which

way they take to descend from the leaves to their respective destinations. First they travel from cell to cell to the veins of leaves and thence through the leaf-stalks to the *inner bark of the stem.* A branch from which a ring of bark down to the cambium layer is removed (fig. 196) will show that the made-up food does not travel in the wood in which the sap ascends. If that branch is examined after one or two years, it will be seen that the stem above the cut has increased in size and that there is a round swelling immediately above the wound. This is due to an accumulation of food, the passage of which was arrested by the cut. Eventually the part of the wood which is laid open will probably be destroyed by parasitic organisms, so that the

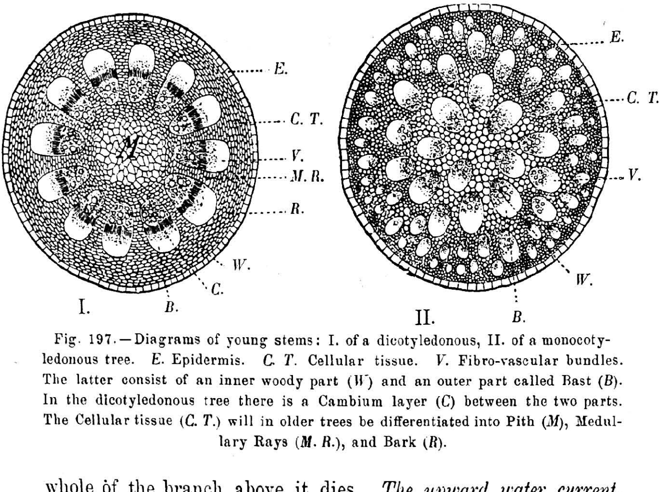

Fig. 197.—Diagrams of young stems: I. of a dicotyledonous, II. of a monocotyledonous tree. *E.* Epidermis. *C. T.* Cellular tissue. *V.* Fibro-vascular bundles. The latter consist of an inner woody part (*W*) and an outer part called Bast (*B*). In the dicotyledonous tree there is a Cambium layer (*C*) between the two parts. The Cellular tissue (*C. T.*) will in older trees be differentiated into Pith (*M*), Medullary Rays (*M. R.*), and Bark (*R*).

whole of the branch above it dies. *The upward water current, then, travels through the younger layers of wood neighbouring the bark, and the downward flow of elaborated food travels in the inner bark adjoining the wood. Between both of them there is the cambium layer where, with the sap from the ground and with the starch from the leaves, new wood is formed.* The woody vessels for the upward current and the bast-cells for the downward current

constitute, in young stems, what is called *fibro-vascular bundles,* lying in a soft cellular tissue. The inner part of the bundles consisting of woody vessels and cells becomes wood, the outer part consisting of soft and hard bast-cells, becomes the inner bark of the woody stem, and the cellular tissue becomes central pith, medullary rays (fig. 198) and rind.

The above is true of exogenous trees. In endogenous trees the two ways for the ascending and descending sap are found side by side in every fibro-vascular bundle, the central part of which consists of vessels for the ascending sap and the outer part of bast-cells and sieve-tubes for the descending sap.

3. Stems as Stores for Food in Reserve.

The leaves of a plant in active operation manufacture more food than what can be used up immediately. The surplus of food is, therefore, laid up for any future emergency.

(*a*) **Storage in Trees.**—The storage in trees is generally not preserved in special growths, but in numberless little cells along the way which the descending sap travels, *viz.* in some cells of the inner bark as also in certain cells which are arranged in rows extending from the inner bark right to the centre of the tree, through the wood-tissue. These rows of cells which are called *medullary rays* appear as silvery rays when a woody stem is cut through transversely. The food in reserve is used by trees in different ways.

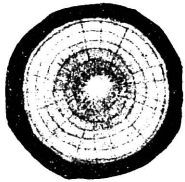

Fig. 198.—Section of the trunk of a Mango tree showing the light alburnum below the bark, the dark heart-wood in the inner layers, the pith in the centre, and medullary rays stretching from the bark into the centre of the wood.

1. Some trees, like the Teak, shed their leaves in the dry season. Most of the trees do the same during winter in cold countries. They begin to grow again with the return of the rains here, or of spring there, and are in a very short time *reclothed with* their beautiful *foliage,* as if by a miracle. This wonderful change is only made possible by the trees availing themselves of the ready-made food deposited

in their stems, which is, when required again, carried to the buds where the plant has, as if by foresight, prepared the future leaves, and, in some cases, even flowers in miniature, before it dropped its leaves.

2. At the time of *flowering* and *fruit-bearing* the consumption of food is so great that a previous storage of it is an absolute necessity. Some trees do not bring forth fruit every year, perhaps because the amount of food stored in one year does not suffice and they require several years' storage to produce their seeds. An instance of this kind is the shrub *Strobilanthes* growing on the slopes of the Ghauts and generally flowering after the lapse of 7 or 12 years. Another instance is the Bamboo known to bear seeds once in 32 years.

(*b*) **Storage in Herbs.**—We now know how trees lay up a store of food in their stems. There are also many herbs that are able to do it. Annual herbs may lay up some food until they produce seeds at the end of the season when they consume the whole storage and die.

Biennials, such as Carrots, store up food in their roots, by which the flowers and fruits of the following year are nourished.

Perennial herbs, however, do not die at the end of a season or two, but let the parts which are above ground wither during the adverse season to sprout again from their underground parts when the rainy season reappears. These underground stems have stores of food in them from which their buds derive their first nourishment when they burst into leaves. These have the following typical forms:—

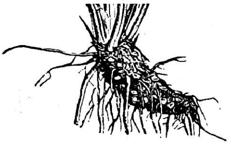

Fig. 199.
Root-stock of Water-Lily.

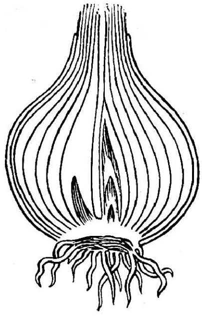

Fig. 200.—Bulb of Onion.

(aa) the *root-stock,* or rhizome (Water-Lily, Ginger, Aroideæ, Ferns, etc.) *i. e.,* a stem running along the ground or under

the ground, sending forth shoots at its upper end and decaying at the other;

(*bb*) the *bulb* (Onion, Crinum, etc.), consisting of a solid stem with large overlapping leaves or scales;

(*cc*) the *tuber* (Potato, terrestrial Orchids, etc.) consisting of a fleshy, roundish mass with buds from which new plants are produced.

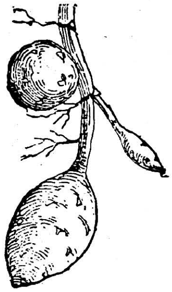
Fig. 201.
Tubers of Potato.

4. THE FLOWER.

We generally look at the flowers as bright and beautiful objects intended to be a source of pleasure to us; but they are created with a different purpose. Every living thing on this earth meets at one time or another with its destroyer, Death. To perpetuate its kind or species it is, however, endowed with the power of reproduction. This work is done in plants by their *flowers*. They produce seeds, from which under favourable conditions new plants of the same kind spring up. And we shall see that everything about the flower is subservient to this one aim.

Many plants are able to propagate themselves also in other ways than by their flowers, as for instance the Hydrocotyle by runners, the Potato by tubers, the Onion by bulbs, the Lotus plant by the branches of its rhizome, the Bladderwort by detached segments of its stem, the Bryophyllum by sprouts rising from its leaves, etc. In all these cases some parts of the plant, other than its floral parts, detach themselves from the mother-plant and become new independent plants. This kind of reproduction is called *vegetative* as compared with *sexual* reproduction by means of flowers and seeds.

Fig. 202.—Shoots arising from the edges of the leaf of Bryophyllum calycinum.

A. The Parts of the Flower.

The essential parts of the flowers are not the beautifully coloured petals, for they fade and fall off after a short time. Those parts, which remain after the petals are no more, and which are for safety placed in the centre of the flower, are more important; they form the fruit and the seeds. We must, therefore, distinguish between the essential *inner organs of reproduction,* the stamens and the pistil, and the *protecting and attracting covers,* calyx and corolla.

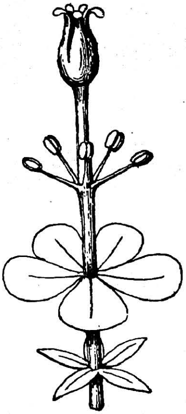

Fig. 203.—The parts of a complete flower: calyx, corolla, stamens, and pistil.

If one of the two floral envelopes is missing, as in the flower of the Castor Oil plant or of the Fig tree, the flower is called *monochlamydeous,* if both are absent as in Colocasia or Pepper, *achlamydeous.* If the flower contains stamens and no pistil, it is said to be *staminate* or male, if pistils and no stamens, *pistillate* or female. In the Papaw tree or the Palmyra Palm staminate and pistillate flowers are found on separate trees. This class of plants is called *diœcious.* Other plants, as the Jack or the Cocoanut Palm, have staminate and pistillate flowers on the same plant, and are, therefore, called *monœcious.*

Fig. 204.—Unisexual flowers of the Papaw tree: *a.* staminate, *b.* pistillate.

1. The Floral Covers: Calyx and Corolla.

The two outer whorls of the flower *fold over and protect the inner parts.* The outer ring, sometimes formed of one whole piece or tube, and sometimes of several distinct leaves, is called

the *calyx,* meaning cup. Its parts are called *sepals.* The second ring is the *corolla* or crown, and is composed of *petals.* The corolla, too, is sometimes in one piece, as in the Coffee or the Tulasi. Such flowers are termed *gamopetalous** or *sympetalous*†; the teeth or lobes of such corollas often indicate the number of leaves they are composed of. Others are composed of 4, 5, or more separate petals, like the Shoeflower and the Water-Lily, and are called *polypetalous*§ or *choripetalous***.

The Lilies, Amaryllids, Orchids, and some other flowers have also two floral envelopes. But as they are both coloured alike, the whole is often called the *perianth*††.

The corolla, whether composed of one compound leaf or of several separate leaves, assumes many forms, as of a tube (Ixora), a cup (Shoeflower), a bell (Pumpkin), a salver or tray (Periwinkle), a tongue (the outer florets of Sunflower), a mouth with 2 lips (Labiatæ), and in the Pea plant somewhat like a butterfly (papilionaceous flower).

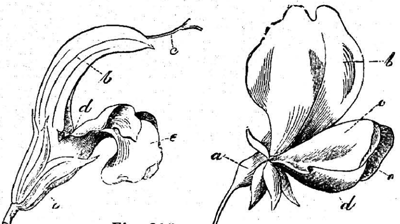

Fig. 205.
Labiate flower. Butterfly flower.

In many plants, these 2 rings of floral envelopes have to protect the delicate inner parts only so long as the flower is in bud. They are in that state (*æstivation*) either valvate (sepals of Hibiscus), or imbricate = overlapping (petals of Hibiscus), or contorted = twisted (Periwinkle). To make the cover complete the sepals and petals generally alternate one with the other. In some plants either the calyx-leaves (Poppy), or the corolla-leaves (Myrtles) fall when the bud opens. In many cases the opened corolla is so constructed that it still affords the inner organs a

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* From Greek *gamos,* marriage. † From Greek *syn,* with. § From Greek *polys,* many. ** From Greek *choris,* apart. †† From Greek *peri,* about, and *anthos,* a flower.

good protection against the weather: In the flowers of some of the Labiatæ the stamens are covered under the upper lip as under a shed; when the wind is strong, the blossoms of the Pea and other papilionaceous flowers turn their back to the wind, so that the inner parts are screened by the standard (*cf.* page 33); the long flower-tube of Sesamum (page 95) is hanging and thus keeps the inner parts safe; some flowers close up their petals during the rain, or at night, and open them only to the sunshine (Water-Lily, page 4).

It is interesting to study also the various ways, in which flowers are protected from browsing animals, snails, and caterpillars, by thorns, spines, and spiny bracts; or how, for instance, in the Plantain or in the Aroideæ a large spathe or bract provides the flowers with the necessary protection.

At the same time the colours of the petals form an *advertisement to insects of the nectar and pollen* stored within.

The petals generally fade and fall after a short time, but in many cases the calyx goes on growing and forms an additional protection to the seeds (Teak, page 107).

2. The Inner Organs of Reproduction: Stamens and Pistil.

(*a*) **The Stamen.**—

After removing the outer two rings of a flower, *viz.,* calyx and corolla, the inner organs, stamens and pistil, are left. We first find a number of threads tipped with tiny knobs or small bags, the *stamens.* If the stamens of the Shoeflower or a Lily are shaken over a piece of paper, a fine yellow powder will drop from them. The threads are called *filaments,* the little knobs or bags at the end of them *anthers,* and the yellow powder which drops from the latter is called the *pollen.* (See also page 144.)

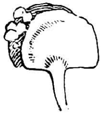


Fig. 206. Stamen of Hibiscus. Pollen-grains issuing from the anther (much magnified).

The stamens vary in number from one in Canna, two in Jasmine, three in Wheat, four in Ixora, five in Thorn-apple, six in Paddy, and so on, up to a

hundred and more in Cereus. They are often distinct from each other, but sometimes grow united into one bundle as in the Mallow family; or they may be in two bundles, as in the Pea-flower tribe, where nine are combined and one stamen is separate; or they may be in several parcels (Citron).

In the Labiatæ there are 4 stamens in two pairs of various lengths, in the Crucifers 6, two pairs longer and one pair shorter. In the Compositæ the filaments of the stamens are free, but their

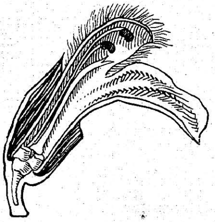


Fig. 207.—Labiate Flower: One pair of longer and one of shorter stamens (only one of each pair visible).

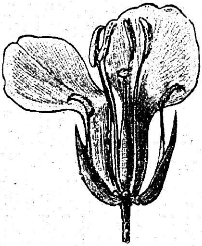


Fig. 208.—Flower of a Crucifer: 4 longer and 2 shorter stamens.

Fig. 209.—Flower of Compositæ: filaments (g) free, anthers (e) united.

anthers are united and form a tube. In the Orchids, again, the stamen is combined with the pistil.

If we put *pollen-grains* into water, they generally absorb at once so much of it that they burst. The same happens, if they are exposed to the rain or to dew. They must, therefore, be protected from the damp of rain or dew. If we sprinkle some pollen-grains over a drop of very weak sugar and water, they do not burst, but throw out long threads. This is what they also do when they are brought on the sticky end of the innermost part of the flower, which is the pistil. The thread grows downwards amongst the tissue of the pistil until it comes to an ovule which is then fertilized.

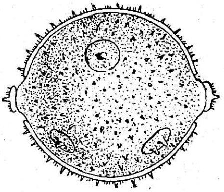
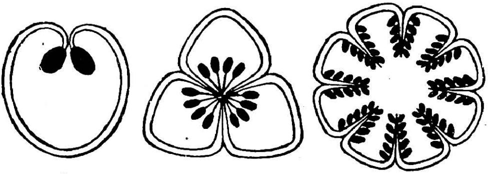


Fig. 210.—A grain of pollen of Cucurbita maxima (magnified 480 times).

(*b*) **The Pistil.**—

The chief part of the *pistil* is the seed-box or *ovary,* containing tiny seeds or rather ovules, which are destined to become seeds, when the fruit ripens after fertilization. This can only happen when the pollen is brought into contact with the ovules. Hence the ovary tapers at its upper end into a more or less slender pillar, the *style.* To enable the style to hold fast the pollen-grains that happen to fall on it, its end, the *stigma,* is provided with tiny warts or hairs which sometimes make it look like velvet (Shoeflower), and also with a sticky liquid which exudes from the surface of the stigma. Some stigmas (Paddy) are feathery. Some flowers, like the Lotus, have no style; the stigma is then said to be sessile.

The ovary is composed either of one or of several leaves, called *carpels**, which are so folded that each forms a cavity. In the Pea which contains one carpel it is folded down the middle with the edges united. Take any leaf, preferably a lanceolate one, and fold it down the mid-rib so that the edges come together, and you produce something not unlike a pea-pod.



1. 2. 3.

Fig. 211.—Structure of ovary: 1. The ovary consists of one carpellary leaf (Pea). 2. It is composed of 3 carpels (Gloriosa). 3. Many carpels form the ovary (Poppy).

In the Tobacco or Chillies there are 2 carpels the edges of which are united and bent to the axis of the ovary so as to form 2 cavities (*loculi*). Similarly, the ovary of Gloriosa consists of 3 carpels, the edges of which all join in the centre of the ovary. The Poppy forms its ovary of numerous carpels the edges of which, however, do not quite reach the centre.

The ovules are, as a rule, attached to the edges of the carpels

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* From Greek *karpos,* fruit.

which form distinct growths, called *placentae.* In a few cases the seeds are not attached to the edges of the carpels but to a pillar-like growth in the centre thus forming a central placenta (Primrose, Basella).

If the ovary is thus formed of several cohering leaves, it is termed *syncarpous;* but if the several carpels of a flower remain separate (Champaca, Rose), it is called *apocarpous.* The ovary of the Pea, though single and composed of one carpel, is also called apocarpous.

(*c*) **The Floral Receptacle.**—The various parts of the flower rest on the more or less enlarged top of a stalk, called the receptacle. If the receptacle is raised in its centre, the ovary lies above the other parts of the flower, and is then called superior (Poppy, Gloriosa). In many cases the receptacle is hollow like a cup, and consequently the ovary stands lower than the other floral parts: the ovary is in this case said to be inferior or half-superior according as it adheres to the cup-like receptacle (Gourd, Crinum), or not (Cinnamon).

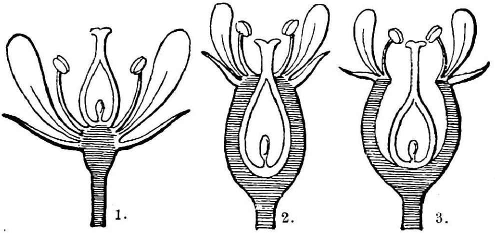

Fig. 212.—Position of ovary: 1. superior, 2. inferior, 3. half-superior.

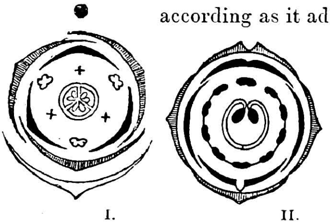

Fig. 213.— I. Diagram of a radial flower (Iris). II. Diagram of a zygomorphic flower (Pea).

3. **Floral Diagram.**—Take the flower-bud of Poppy and cut it transversely a little above the receptacle and study the figure on the cut. You will recognize all the parts of the flower. If it is not possible to get all the parts of the flower by one cut, various sections at different

heights must be made, and the result combined in one diagram to show the structure of a flower in a ground plan.

The diagram of the Poppy or the Gloriosa may be divided into equal halves by various diagonal sections and the parts of the flower appear as grouped like radii, hence they are termed regular or *radial flowers.* The diagram of the Pea or the Orchis can be divided into equal halves only by one section; such flowers are called *zygomorphic*, i. e.,* forming a pair or yoke.

B. The Function of the Flower: Pollination.

1. Various Provisions for Cross-pollination.

Most flowers have stamens and pistils growing together on the same flower. It does not follow from this, however, that the pistil of such a flower is fertilized from its own stamens. This would be called self-pollination. Although cases of this kind do occur in nature, they are not at all common. It has been proved by many careful observations and experiments that plants on which the flowers have been self-pollinated, bear poor and insignificant fruit. As a rule, pistils are fertilized by pollen from other flowers, and to ensure such **cross-pollination** many wonderful and interesting arrangements exist, which we shall now consider.

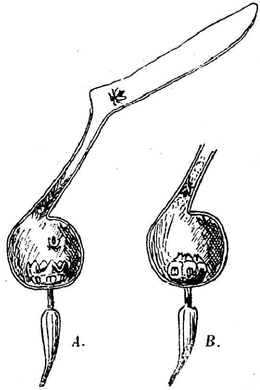

Fig. 214.— Aristolochia. *A.* Stigma mature before ripening of stamens. *B.* Pollen developed after fading of stigma.

(*a*) Stamens and pistils are *distributed over different flowers* (monœcious and diœcious plants).

(*b*) In some plants, where the stamens and pistils do occur in the same flower, these organs *mature at different times:* in the

* From Greek *zygon*, a yoke, and *morphe*, shape.

Sunflower the stamens open when the stigma is still undeveloped; but in the Aroideæ and in Aristolochia the stigma is mature before the stamens develop their pollen.

(*c*) If both mature at the same time, the stamens and pistils are sometimes *so placed that the pollen cannot easily reach the pistil* of its own flower (Hibiscus).

(*d*) The flowers of the shrub *Clerodendron infortunatum* (*Can.* Iṭṭēvu; *Mal.* Peragu) exhibit a remarkable contrivance for cross-pollination. The white corolla and the strong, sweet scent make the flower conspicuous at dusk to moths which stretch their long tongues into the flower-tube to obtain the nectar hidden in its depth. While thus hovering in front of the flower they touch the anthers of the 4 stamens that protrude from the flowers. The *style* of these flowers is *bent back* in a long downward arch. The moth will then move on to another flower which may have opened the previous night and now has its stamens curled up but the *style straight,* so that the moth cannot help touching and thus pollinating it with the pollen of the flower from which it came.

1. 2. 3.

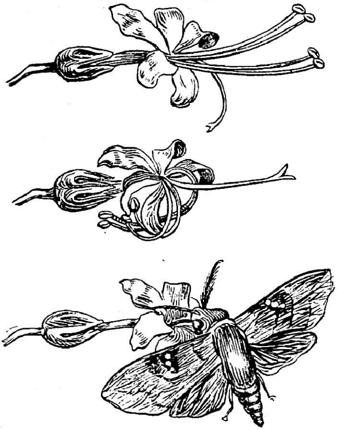

Fig. 215.—Flowers of Clerodendron.
1. First position of stamens and style.
2. Second position of the same.
3. Moth visiting the flower of Clerodendron.

(*e*) We have found another contrivance to avoid self-pollination in the Orchids (page 153), where the pollen-masses are in separate pouches and can only be removed by a bee which carries them to another flower to pollinate it.

As cross-pollination is advantageous to the plant, and as the plant is unable to move, it requires some assistance to carry the

pollen from one flower to another. This is obtained from insects or from the wind.

2. Pollination by the Agency of Insects.

(*a*) **What the plants can offer to their guests.**—The conveyance of the pollen from one flower to another is not done by animals purposely or voluntarily. They pay the plants visits for their own sake only. But while obtaining some benefit from the plants they, in their turn, unconsciously render them a very useful service in carrying their pollen to the next flower. What they seek and find in the flowers is first of all a sweet juice, called nectar. (It is not honey, but becomes honey in the body of the bee.) This sweet liquid is secreted by certain glands forming the *nectary* and belonging to any of the floral parts, calyx, corolla, stamen, pistil or receptacle (*cf.* Gloriosa, Mango, Aristolochia, Bindweed). In addition, there are often streaks or dots upon the corolla pointing the way to the nectar; such *nectar-guides* are seen, for instance, in the Mango. It is generally hidden away in the depths of the flower, and the insect must, therefore, either be furnished with a long tongue, like butterflies and moths, or must actually get its body right into the corolla, like the bee. The humble bee, for instance, when visiting a labiate flower, alights on the lower lip of the corolla, which is admirably suited for a landing place. The weight of the insect naturally bears the flower down, and, as the bee pushes its body into the throat of the flower to reach the nectar at the bottom, its back comes in contact with the anthers and rubs off some of the pollen. This is unconsciouly carried to the next flower visited, and some is rubbed off by the style.

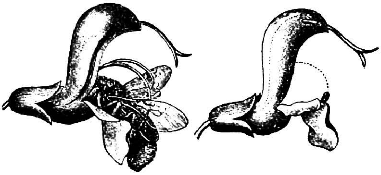

Fig. 216. — Bee visiting the flower of Salvia.

Besides nectar, many flowers offer them their *pollen* as food.

Several flowers possess no nectar at all, but instead of it plenty of pollen in their numerous stamens (Poppy, Rose). These flowers are erect and have the shape of shells or cups, so that the falling dust may not be spilt and lost (page 6).

Some flowers offer their visitors nice and snug homes to live in for a while (Aroideæ, Aristolochia); and the Banyan tree even allows the small midges that can enter the little openings of the figs, to lay their eggs in the figs (page 112).

(*b*) **How the plants attract visitors.** (i) COLOURS.—The petals of the flowers are usually brightly coloured, and are readily seen from a distance. If the corolla is inconspicuous, the bracts may become coloured as in Bougainvillea. In Mussænda (*Can.* Bellotti; *Mal.* Vellila) one calyx-lobe is much enlarged and looks like an ordinary leaf, but is white. Flowers that open in the evening and must, therefore, be pollinated by night-moths, are generally white or pale, so as to be easily seen in the twilight (Jasmine, Crinum, Clerodendron, Nyctanthes, etc.).

Fig. 217.—Mussænda frondosa. The large white leaf is one of the 5 lobes of the calyx.

(ii) INFLORESCENCES.—Another help to make the flowers conspicuous to visitors is their arrangement in greater numbers on a flower-stalk (peduncle), forming what are called inflorescences. They are thus raised over the foliage and afford easy access.

When the peduncle rises directly from the root, as in the Water-Lily or in Crinum, it is called a *scape*. The inflorescences can be referred mainly to 3 original types: the raceme, the umbel, and the cyme.

(*aa*) *In the racemose or indefinite inflorescence* (fig. 218—220) the principal axis (peduncle) goes on elongating and gives off secondary branches (pedicels), each of which bears a flower. In these the flowers furthest from the top of the axis open first. (This is shown in the illustration by the various size of the circles denoting the flowers.)

When the peduncle bears stalked flowers, the inflorescence is called a *raceme* (Mustard, Indigo), and when these secondary branches are forked again, a *panicle* (Mango, Cinnamon, Paddy). When the flowers are sessile on the peduncle, we have a *spike* (Pepper-Vine, Habenaria).

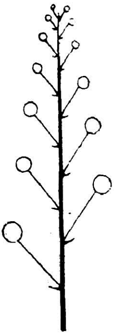

Fig. 218. Raceme.

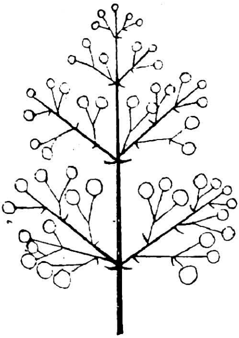

Fig. 219. Panicle.

Fig. 220. Spike.

(*bb*) *In the umbellate inflorescence* (fig. 221 and 222) the main peduncle grows to a certain point and is then suddenly divided into many pedicels of equal length.

When the flowers are spread out, each borne on a pedicel radiating like the ribs of an umbrella, we have an *umbel* (Crinum). When each pedicel of an umbel gives rise to another umbel, the umbel is called compound (Carrot). When they are sessile and crowded in a dense mass, we have a *head* (Compositæ).

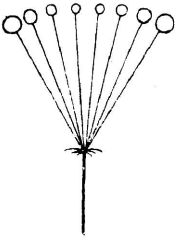

Fig. 221.—Umbel.

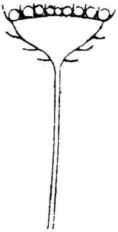

Fig. 222.—Head.

(*cc*) *Cymose or definite inflorescences* (fig. 223). The central axis is terminated by a flower and does not elongate. But below this flower, which opens first, one or several lateral peduncles are given off. These are again terminated by a flower and again forked like the main peduncle (Clerodendron). If the peduncles of a cymose inflorescence are comparatively short, so that the flowers appear to be in one plane (as in an umbel), the inflorescence is termed a *fascicle* (Ixora).

(iii) Scents.—Strong and various scents are also great helps to attract insects. The bee-tribe and butterflies are specially attracted by the sweet scent of Roses, Peas, etc., and the powerful scents emitted by such flowers as the Jasmine, Tobacco, and Crinum as evening comes on, tend to guide the nocturnal moths to them.

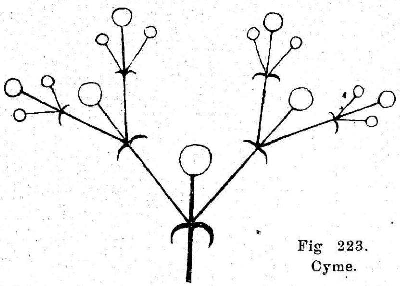

Fig 223.
Cyme.

Sometimes the odours used to attract insects are the reverse of pleasant to us. As an instance the Nux-vomica tree may be mentioned, or *Aristolochia gigantea* (*Can.* Bātkōḷi hūvu).

Scentless flowers usually have some equivalent form of attraction, such as gaudy colours, abundance of pollen, or the grouping of a number of small florets; whereas inconspicuous flowers are often endowed with a particularly strong smell (Violet).

3. Pollination by the Agency of the Wind.

Among the plants whose flowers are pollinated by the help of the wind, the chief are the Grasses. The principal characteristics by which such plants may be recognised are:—

1. The flowers are *inconspicuous, scentless* and have *no sugary secretions*.

2. Their *anthers hang out of the flower,* so that the pollen can be easily set free and carried away by the wind.

3. The *pollen* is produced very *abundantly* to allow for wastage.

4. The *pollen-grains are dry* and *small* and, therefore, *light.*

5. The *stigmas are large* and *feathered,* so that pollen-grains floating in the air are easily caught.

5. THE FRUIT AND THE SEED.

A. How the fruits are formed.

(*a*) **The Covering.**—When the little ovules in the ovary or seed-box are fertilized, the outer part of the flower fades away, its end having been attained, and the ovary begins to develop and becomes the fruit, which, under a well-protecting cover, called *pericarp,* contains the ripening seeds.

This cover is made up primarily of the walls of the ovary itself. But sometimes a swollen peduncle (Cashew Nut), or a hollow fleshy receptacle (Rose, Jamoon) also helps to form the fruit.

Generally, a single, perfect or pistillate flower produces a *single fruit,* but where the ovary has distinct carpels, distinct fruits may sometimes be found (*Uvaria narum*—*Can.* Uṇāmiṇi). On the other hand, where a number of flowers grow on a common receptacle, a single fruit sometimes is the result, as in the Pine-apple (which is made up of the ovaries and floral envelopes of several flowers combined), or the Jack-fruit and the fig of the Banyan tree. These fruits are called *aggregate fruits.*

The pericarp affords *protection* to the seeds in various ways. The soft and sweet fruits, which are so tempting to men and animals, do not, as a rule, sweeten or attain a bright colour before the seeds are quite ripe. All through the period of growth the pulpy mass, with which the seeds are surrounded, is either sour or bitter, and is usually green, the colour of the leaves.

Again, such fruits as the Cocoanut are protected by a fibrous covering and a hard shell. Others like the Mango, have a hard covering inside the pulp. Many others have their outer coats covered with prickles, for the same reason. A very striking example of this is *Mucuna pruriens* (*Can.* Nāyisoṇagu; *Mal.* Nāyikuruṇa), which has pods like a Bean, but all covered with short, red, stinging hairs which cause a most intolerable irritation. Another kind of protection is the change of position of the fruit after fertilization, as in the Water-Lily, the capsule of which is drawn under the surface of the water to ripen.

(*b*) **The Seed.**—With the growth of the covering of the fruit the seeds inside are formed of the fertilized ovules, which are, so long as they require nourishment, attached to the placenta by a cord, called the *funicle*. When the seeds are mature, the funicle withers, and leaves a scar on the seed, the *hilum*.

The structure of the seed is simple. Inside the coat, called the *testa,* we can distinguish 2 parts: the germ or *embryo,* and the *food-store*. The germ contains all the essential parts of the plant, namely the root (radicle), and the stem and leaves (plumule), as can be clearly seen in the tiny bud between the seed-leaves or cotyledons of a Bean or a Pea. The food-store is either deposited in a separate nourishing tissue, called *endosperm,* surrounding the germ under the seed-coat (Tobacco, Castor-Oil Plant, Cocoanut, Rice, Maize), or in the seed-leaves (Bean), which then swell into thick masses. The number of the seed-leaves (cotyledons) marks two large classes of the flowering plants, *viz.,* the dicotyledons (plants with two cotyledons) and the monocotyledons (plants with one cotyledon).

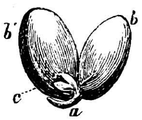

Fig. 224.—Seed of the Bean: *a*. Radicle. *b*. Cotyledons. *c*. Plumule.

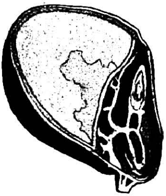
Fig. 225.—Endosperm in seed of Maize.

When the seeds are mature and their germs in a position to live alone, they must leave the protecting covering (pericarp) and be dispersed, so as not to germinate just under or near the mother-plant where the young plants would simply suffer from her shade, and from the fact that she had used up some of the supplies of mineral food available, and that they would have a hard struggle for life with one another. The germs or young plants must, therefore, be so constructed as to be able to go on a long journey without perishing. They are in this state in the ripe seed. When fully formed, they cease to be watery, the place formerly occupied by water being now filled with starch or oil, and the seed-coat becomes hard.

Many seeds, it is true, do not end their journey in a very

suitable place, but die by hundreds and thousands for want of congenial surroundings, and it is for this reason that such large numbers of seeds are produced.

B. How the fruits allow their seeds to escape.

In order to enable the seeds to start on their journey, the fruit which had to protect them during the period of growth and ripening, must set them free. This is done in various ways according to the kinds of fruit.

(*a*) Some **dry fruits open** naturally, when the seeds are ripe, to let them out. Such *dehiscent* fruits are:—

The **Legumes,** like those of the Pea, which split into two valves and in which the seeds are not divided by a central frame;

the **Siliques** and **Silicules,** like those of the Mustard, opening by two longitudinal slits, forming also two valves, but with a central frame to which the seeds adhere;

the **Follicle,** also two-valved, but opening by one longitudinal slit only, and with the seeds variously distributed, like the fruit of the Asclepiadaceæ;

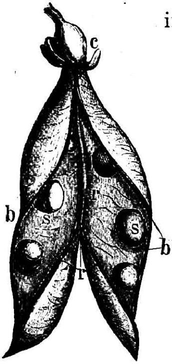

Fig. 226.
Legume of Pea.

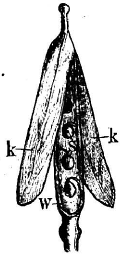

Fig. 227.
Silique of a Crucifer.

the **Capsule,** sometimes splitting into various valves (Sesamum),

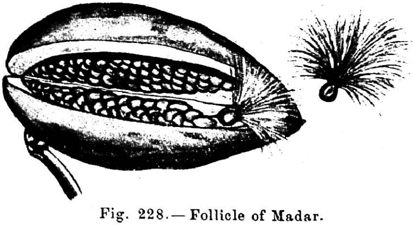

Fig. 228.—Follicle of Madar.

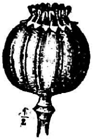

Fig. 229.
Capsule of Poppy.

or breaking up irregularly, or opening by small holes (Poppy).

(*b*) **Dry Fruits that do not open** (*indehiscent* fruits) are either one-seeded like the *achenium* of the Sunflower, and Grass-seeds; or many-seeded like the dividing fruits (*schizocarps*) of the Labiatæ, where the carpels separate from the axis each containing one seed.

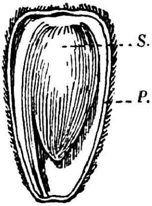

Fig. 230. Achenium of Sunflower (opened). *P.* Pericarp. *S.* Seed.

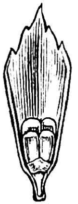
Fig. 231. Schizocarp of Tumbe. (Front part of calyx removed.)

(*c*) **Fleshy Fruits** do not open by themselves. They either rot on the ground and thus set the seeds free, or are eaten by animals, which digest the flesh and reject the seeds. Such are the **berries**, with many seeds, as the papaw, the guava, brinjal and banana; and the **drupe**, with one seed, generally enclosed in a hard shell, as the mango.

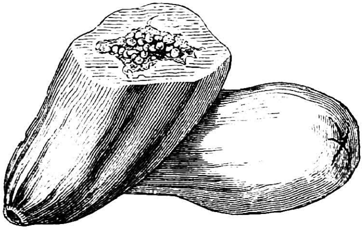
Fig. 232.—Berry of the Papaw tree.

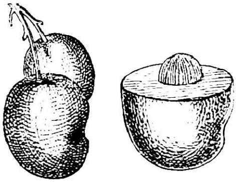
Fig. 233.—Drupe of Mango.

C. How the seeds are dispersed.

It is not enough that fruits should allow their seeds to escape. If they would only fall down and begin life again directly under the leaves of the parent plant, they would, as already stated, not get sufficient light and air, and would find a soil from which a great deal of the plant-food had already been extracted by the mother-plant, and would starve. To ensure the dispersion of the

seeds over a wide area, various wonderful provisions are made. As the plants cannot move of themselves, they often make use of the agency of running water, of wind, animals and birds, and with their help undertake long journeys to distant countries and even cross oceans.

(*a*) **Dispersed by mechanical contrivances.**—Some plants contain, within themselves, the means necessary to scatter the seeds. This is in some cases an *elastic force* by which the seeds are thrown away from the parent plant, as in the capsule of Balsams. "The seed-pod is generally in a state of tension, due to the gradual drying up of the tissue. Then a puff of wind, a slight blow, or even a change in the atmospheric condition of the air, gives the final impetus, causing the pod to burst with such force that seeds are thrown out in all directions" (*Brightwen*).

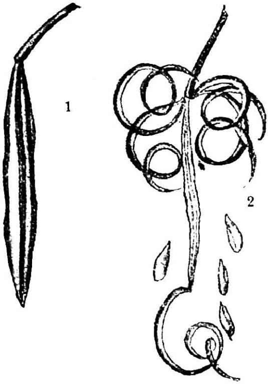

Fig. 234.—Capsule of a Balsam: 1. closed, 2. exploding and scattering the seeds.

In other cases, the seeds are furnished with *awns,* as in many Grasses. Each awn is thickly set with bristles which allow the awn to move only in one direction. As these are sensitive to moisture, the difference in the amount of moisture in the air lengthens and contracts them, so that the seeds attached to them are slowly but surely drawn away many inches.

(*b*) **Dispersed by water.**— Many water-plants have seeds or fruits which float. An air-bubble is attached to the seed of the Water-Lily which causes it to rise to the surface. The cocoanut is provided with a strong, but light covering, and, if it falls into the sea, it may be carried by the waves hundreds of miles. How many seeds that fall to the ground during the hot season are washed away by the torrents of rain of the bursting monsoon and landed on a spot far away from the mother-plant,

the hard seed-shells protecting the tender germ within from destruction!

(*c*) **Carried by the wind.**—We are all familiar with the winged fruits of so many trees, such as Hopea Wightiana (*Can.* Karmara; *Mal.* Ilapoṅgu; *Tam.* Koṅgu) or Hopea parviflora (*Can.* Bōvu, bōgi) in which 2 sepals are enlarged and become wings in the fruit, and with the winged

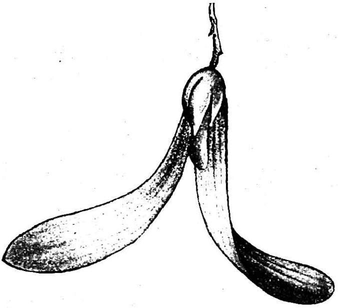

Fig. 235.—Winged fruit of Hopea Wightiana.

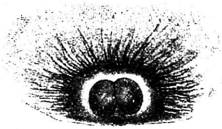

Fig. 236.—Winged seed of Stereospermum.

appendages of the seeds of Stereospermum (*Can.* Puruḷi; *Mal.* Pātiri; *Tam.* Pādiri). The fruits of many Compositæ and Asclepiadaceæ are provided with silky or feathery hairs (called "pappus" in Compositæ), which catch the wind and allow the seed to be borne away even by the gentlest breeze. In some cases, as in the Poppy and Ladies' Fingers, the capsules are placed on long stalks, which the wind shakes with so much force that the seeds are thrown away as from a sling.

Fig. 237.—Seeds of Vernonia dispersed by wind.

(*d*) **Dispersed by animals and birds.**—This is done either unconsciously or consciously: unconsciously, when the seeds by their hooks or bristles become attached to the skin of animals, or by the sticky mass of their

pulp (Loranthus) to the beaks of birds which carry them away; consciously, when animals or birds, attracted by the bright colour and the fragrant smell of succulent berries and drupes, revel upon the sweet, soft flesh, but reject the seeds (Mango). If they swallow the seed also, the latter is enabled to resist the action of digestion by its hard covering and passes through the animal undigested (Coffee, Fig).

D. How the seeds produce new plants.

When a seed has thus finished its journey and has found favourable conditions (warmth, moisture, and air) on the spot where it has finally settled, it awakes from the state of rest in which the germ contained in it has tided over a season that might have been fatal to its life, and begins to germinate. First it absorbs moisture through its skin. This, combined with warmth and the oxygen of the air, sets up a change in the condition of the seed. The germ swells, breaks the seed-skin, and begins to grow: the tiny root of the embryo lengthens and grows downwards, while the other part stretches upwards. For this first process of growth the young plant requires the food-store provided by the mother-plant. It can be observed in every germinating seed, how the supply of food is gradually exhausted as the plant grows. And it lasts just long enough for the young plant to form roots and green leaves by which to obtain its nourishment direct from the soil and air. (See germination of Pea p. 28, of Cucumber p. 55, and of Rice p. 161.)

APPENDIX.

1. Nomenclature and Classification of Plants.

1. **Species.**—The fact that plants, reared from the seeds of a mother-plant, are like each other and like the parent, is familiar to everybody. Thus plants that spring from the seeds of a Banyan tree become Banyan trees again, and such as spring from Cucumber-seeds become Cucumbers. All such plants, therefore, which appear to have sprung from the same parent, and agree with each other in all essential parts, constitute a *species*.

There is, however, some variation in the development of the various parts of plants belonging to the same species, which is caused by differences of soil, climate, and other conditions. In identifying plants beginners must, therefore, distinguish between essential and accidental variations (*cf.* Tumbe, page 98). The following extract from Sir Jos. Hooker gives the chief causes of such variations:—

"A bright light and open situation, particularly at considerable elevations, without too much wet or drought, tends to increase the size and heighten the colour of flowers in proportion to the stature and foliage of the plant. Shade, on the contrary, especially with rich soil and sufficient moisture, tends to increase the foliage and draw up the stem, but to diminish the number, size, and colour of the flowers. A hot climate and dry situation tend to increase the hairs, prickles, and other productions of the epidermis, and to shorten and stiffen the branches. Moisture in a rich soil has the contrary effect. The neighbourhood of the sea, or a saline soil or atmosphere, imparts a thicker and more succulent consistence to the foliage and almost every part of the plant, and appears not unfrequently to enable plants, usually annual, to live through the winter.

"The luxuriance of plants growing in a rich soil, and the dwarf, stunted character of those crowded in poor soils, or in the cold, damp regions of high mountain-tops, is well-known."

2. **Genera.**—We have seen that the Banyan tree (*Ficus bengalensis*) constitutes a species. If we muster the vegetable kingdom, we can easily find other trees which resemble the Banyan tree in most important points of structure, such as the Peepul tree or the Country Fig tree. Such plants form one *genus, viz.,* the genus "Ficus".

3. The **Scientific Nomenclature** of plants is based on this classification into species and genera. Thus the Banyan tree is known as *Ficus bengalensis* and the Peepul tree as *Ficus religiosa,* the common first name "Ficus" denoting the genus, and the second "bengalensis" or "religiosa", the species.

Plants have, of course, also popular names; but as these vary not only in various countries, but even in different parts of the same country, and as different plants are also called by the same name in different parts of a country, such popular names are useless for students of botany. Hence scientific names, derived from Latin and Greek, are applied to plants, by which they are known to all educated people of the world.

4. **Families, Classes, etc.**—Several genera which agree in certain marked characters, constitute a family, and several families still larger divisions. In this manner we have grouped:

the *genera* of Gossypium, Hibiscus, Bombax, etc., under the *family* of Malvaceæ;

the *families* of Malvaceæ, Cruciferæ, Rosaceæ and others under the *sub-class* of Polypetalæ (= plants with separated petals);

the *sub-classes* of polypetalous, gamopetalous (= of united petals) and monochlamydeous plants (= having a single instead of a double floral cover) under the *class* of Dicotyledons;

the *classes* of dicotyledonous and monocotyledonous plants under the *division* of Phanerogams (= flowering plants);

and the two *divisions* of phanerogamous and cryptogamous (flowerless) plants under the Vegetable *Kingdom.*

2. Distribution of Plants.

1. Any ramble through the neighbourhood of our houses teaches us that plants are variously distributed. Some prefer the open field as their habitat, others the shady woods; some, the rich loam near rivers and tanks; others, the dry and rocky soil of hills or deserts. It is **the difference of soil, light, and moisture,** which thus conditions the change of vegetation in various places.

2. An excursion into remoter parts of our country, or to the top of a high mountain, shows a still greater difference. This is due to **the change of the climate,** *viz.,* heat and moisture, in various parts of India.

So, when we ascend a mountain of the Himalayas, we have to travel through different belts of vegetation: about the base we find Palms and Bananas; a little higher, Bamboos, Figs, Ferns, etc.; higher up, Myrtles and Laurels; then Conifers and dwarf-trees; and in the highest regions the flowering plants cease to grow more and more, and leave the place to Mosses and other Cryptogams.

The same succession of different classes of plants is noticed by travellers from the equatorial to the polar regions of the earth.

3. An important part in the distribution of plants is played **by man.** It is he who has brought new plants from foreign countries and from far remote continents to our land (Spanish Pepper, Coffee, Tobacco, Potato, and many others); who has cultivated large tracts of land with food-crops and other useful plants (Cereals, Pulses, Cotton, Opium, etc.), and suppressed the indigenous weeds that were growing there before; who cuts down forests to plant crops more useful to him; who drains swamps and irrigates deserts to make them fertile.

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CORRECTIONS

Page 14, line 26 : *read* a family which is *for* which are.

„ 14, l. 32 : *read* is *for* are.

„ 16, l. 7 from the bottom: *read* is *for* are.

„ 24, l. 15: *strike* and consequent want of water, *substituting* and by intense light.

„ 24, l. 19: *add* as well as that of intense insolation *after* heat.

„ 24, *read* Fig. 20 *for* Eig. 20.

„ 47, l. 3 from the bottom: *read* Xerophilous *for* Xyrophilous.

„ 54, l. 6 from the bottom: *read* Bryophyllum *for* Bryophillum.

„ 64, l. 14 from the bottom: *read* 15 *for* 5.

„ 81, l. 11: *read* Scramblers *for* Straddling climbers.

„ 113, l. 3: *read* Araçamaram *for* Aaraçamaram.

„ 138. l. 9: *read* Phœnix *for* Phænix.

„ 173, l. 3 from the bottom: *read* diœcious *for* monœcious.

„ 191, l. 6 from the bottom: *strike* together with the starch.

„ 191, l. 2 from the bottom: *add* and starch *after* albuminoids.

„ 209. l. 6 from the bottom: *read* inhale *for* breathe; *add* and expel Carbon dioxide *after* Oxygen.

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